Aids
Series

Aids to Tropical Hygiene

Alfred C. Reed
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AIDS
TO
TROPICAL HYGIENE

BY

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WITH A PREFACE BY
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ENLARGED, THOROUGHLY REVISED, AND MOSTLY RE-WRITTEN

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I HAVE eaten your bread and salt,
I have drunk your water and wine ;
  The deaths you have died
  I have watched beside,
And the lives ye live were mine.

Was there aught that I did not share
  In vigil, or toil, or ease ;
One joy or woe that I did not know,
  Dear hearts across the seas ?

KIPLING.

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PREFACE

I HAD the pleasure of bringing this book to the notice of the medical profession in America when I was in the United States. I felt then, as I feel now, that a concise and handy book of this nature is likely to be of great value, and should prove of very considerable assistance to young medical men who may find themselves — possibly unexpectedly—quartered in an outlying part of the globe.

T. H. J. Goodwin, Lt: Genl.
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June 17, 1922.

TO

MY WIFE

WHOSE CHEERY COMRADESHIP HAS

LIGHTENED THE BURDEN OF MANY LONG YEARS

OF TROPICAL EXILE

AUTHOR'S PREFACE

SINCE the last edition of this book was published, the Allied Armies have campaigned in many tropical theatres of war, and a great deal of work has been done by various investigators in all parts of the tropical world.

The result has been an immense increase to our store of knowledge, which has necessitated not merely the revision, but the rewriting, of the greater part of the volume.

I have been fortunate in having the valued and learned assistance of two of my brother officers, with wide and varied tropical experience — viz., Lieut.-Colonel J. T. Johnson, D.S.O., an Assistant Director of Hygiene, and Lieut.-Colonel J. Mackenzie, an Assistant Director of Pathology.

I am much indebted for their help, and trust that our labours have been successful in maintaining in this edition the twofold aim of its predecessor—viz. : (*a*) to provide the student for the D.T.M.H., and the Major, R.A.M.C., going up for his promotion test, with a ready means of revising his reading before examination; and (*b*) to furnish the junior practitioner with a handy pocket-book containing a summary of the main facts with which the Health Officer in the tropics must be acquainted.

I acknowledge my deep obligation to the authors in

the list of references, from all of whose valuable works I have freely quoted, but it has been obviously impracticable to indicate in a book of this nature the source of each quotation.

In view of the wide circulation in various parts of the New World, I have had constantly in mind the needs of the reader in America, and trust this "Aids" may be accorded the kind reception given to the former edition on that continent.

R. J. BLACKHAM, M.D.

ARMY AND NAVY CLUB,
PALL MALL, S.W.
July, 1922.

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AIDS TO TROPICAL HYGIENE

CHAPTER I

THE CLIMATE OF THE TROPICS

THE present-day distribution of civilization supports the view that tropical or subtropical regions are unsuited to the more civilized races. Our most progressive communities are located in temperate regions, and any invasions of the tropical or semitropical zones by representatives of northern civilizations have either suffered rapid decline or have been kept vigorous only by constant reinforcements from their source.

However, this superiority of the colder latitudes as a place for human development has not always existed. Almost without exception, the parent sources of human progress have been in tropical, or at least subtropical, countries; Mesopotamia, Egypt, and Asia Minor all represent sites of apparently original civilizations, and are located well within the warmer zones. The mysterious relics of Central America, Mexico, and Peru are similarly situated, and if in the latter case the altitude is such as to modify climatic conditions, there is evidence to show that marked elevation has taken place comparatively recently, and that the more ancient remains antedate this elevation.

If, then, the tropics, originally the source of human culture, have been incapable of maintaining it, some change in condition must be responsible. The probable explanation lies in the spread of the so-called tropical diseases, owing to the increased exchange of people and products so characteristic of later years. The decline

of Greece and Rome have been ascribed to the introduction of malaria with African slaves, and in America we have even better established instances of this sort. Torquemada, speaking of Yucatan, itself a site of prehistoric civilization, says : " Men die here of pure old age, for there are none of those infirmities that exist in other lands ; and if there are slight infirmities the heat destroys them, and so there is no need of a physician there." But with the coming of the white man and the negro, with their alien diseases, conditions changed until Southern Mexico and Central America became notorious as hotbeds of tropical fevers.

With progress in sanitary science it has been hoped that this position of the warmer latitudes might undergo another alteration, as in Cuba and Panama the possibility of mastery over these diseases has been shown.

Our interest in the subject is greater than any other nation, as few people fully realize that in addition to India, Ceylon, the Straits Settlements, and many tropical islands, the British Empire in Tropical Africa now covers an area of 2,628,000 square miles, with a population of nearly twenty-eight millions.

In his work " The Dual Mandate in British Tropical Africa, 1922," Sir F. D. Lugard points out that this population, though small for so vast an area, is double the density of French Tropical Africa, if we exclude the Sahara; whilst its trade, which is rapidly expanding is more than double that of India per head of population, and is equal to that of Japan.

The tropical zone, which embraces nearly half the earth's surface, has been bounded—

1. By the Tropics of Cancer and Capricorn, latitude 25° 5′ north and south.

2. By the mean annual isotherms of 68°.

3. By the polar margins of the trade winds.

The dominant characteristic of all tropical climate *is the regularity* in the occurrence of the ordinary *weather phenomena.*

They lack the proverbial changeableness which characterizes the weather of higher latitudes.

In special regions only and at special seasons the regular sequence of weather is temporarily interrupted by an occasional tropical cyclone.

The devastation produced by one of these storms often affects the economic condition of the people in the district of its occurrence for many years.

The region has been divided into four belts—viz. :

1. The equatorial belt.
2. The trade-wind belt.
3. The monsoon belt.
4. Mountain climates.

The characteristics of the four divisions may be summarized as follows :

1. **The Equatorial Belt.**—This belt is subject to alternate seasons of wind and calm—*e.g.*, in January it is subject to the north-east trades, followed by a period of calm ; and in July to the south-east trades, succeeded by another period of calm. There are, therefore, two maximal and minimal temperatures after two zenithal and solstitial positions of the sun, and two short wet seasons and two short dry seasons.

2. **Trade-Wind Belt.**—The character of the trade-wind belts is very regular, with diurnal ranges of temperature, and either complete absence of rain or slight showers at infrequent intervals. The range of temperature in the desert is often very great ; thus during the day the temperature may be very high, with dry winds carrying dust and sand, and the night with a clear sky, free from cloud, allowing active radiation, may be cool, or even at times quite cold.

3. **Monsoon Belt.**—In typical monsoon regions the rains follow the vertical sun, and the type of temperature is the so-called tropical type, with one maximal and one minimal (Castellani).

4. **Mountain Climates.**—If tropical mountains are high enough they carry snow the year round, even near the equator, and the zones of vegetation may range from the densest tropical forest at the base to the snow on the summits. The highlands and mountains within the tropics are thus often climatically in sharp contrast with the lowlands, and offer more agreeable and more healthful conditions for white settlement. The climate of many tropical plateaus and mountains has been happily described as a "perpetual spring."

Herschel many years ago showed that for every 300 feet of increase in altitude there was a decrease of 1° F. in temperature, and for every 180 metres a decrease of 1° C. These statements are only partially correct, as the temperature at a given altitude depends upon four factors—viz., (*a*) Expansion and humidity of the air; (*b*) clearness of the atmosphere; (*c*) quantity of earth at the observation point; (*d*) nature of wind blowing at the time.

(*a*) *Expansion.*—This is most important, as, when heated air expands, the energy represented by heat is converted into motion, and the temperature falls.

(*b*) *Clearness of Atmosphere.*—This is in part counteracted by the heat produced from condensation of aqueous vapour, as on the presence or absence of clouds depends the amount of radiant heat retained.

(*c*) *Quantity of Earth.*—The lessened amount of earth in high altitudes is a factor, because there is less ground to retain heat.

(*d*) *Winds.*—Obviously the movements of the air must have great effect according to whether the winds take their origin from warm or cold sources.

In view of these four factors the relationship between temperature and altitude is only approximate.

Carbonic acid, sulphuretted hydrogen, and carburetted hydrogen (CH_4), are generally present in some excess, *together with* decaying organic matter, both in the form

of vapour and of suspended matter, in the air over marshes. The suspended matters consist of vegetable débris, diatoms, algæ, fungi, bacteria, and other micro-organisms. The symptoms of anæmia and prostration so frequent amongst residents along the banks of marshes are attributed to the presence of H_2S in the air.

The following points with reference to tropical climates require consideration:

1. Temperature.
2. Seasons.
3. Barometric pressure.
4. Winds.
5. Rainfall.
6. Storms.
7. Tropical sunlight.
8. Altitude.
9. Physiological effects of tropical residence.

1. **Temperature and Humidity.**—Temperature is one of the most important factors in determining a climate. Man can bear very high dry temperatures without discomfort, but cannot stand much lower temperatures if the air is humid. It is the rate at which the skin surface cools rather than the actual temperature which influences sensations of comfort. According to their environment, the sense of comfort of individuals must bear a close relation to the range of variation of climatic conditions they usually experience, plus the purely personal physiological factor depending on general health, mode of life, etc. (Kenwood). Humidity is due to aqueous vapour caused by the evaporation from the surface of oceans, lakes, or rivers, and plays a most important part in the effects of tropical climate. The sun reaches its highest azimuth in the tropics, hence the mean temperature is high; it is very uniform over the whole zone, and there is little variation during the year. The mean annual isotherm of 68° F. or 20° C. marks the polar margins of the zone, and the mean annual isotherm of 80° encloses the greater portion of the land areas, as well as much of the tropical oceans. The isotherms are thus far apart. The warmest latitude for the year is not the equator, but north latitude 10°.

2. **The Seasons.**—The variations in temperature throughout the year are so slight that the seasons are not classified according to temperature, but depend on rainfall and prevailing winds. The life of animals and plants and of man himself in the tropics is regulated very largely by the rainfall. Agriculture prospers or fails according to the sufficiency and punctual appearance of the rains. After a long dry season, when rain comes there is a remarkable sudden awakening of parched and dusty vegetation; but where, as frequently occurs, there is abundant moisture throughout the year, a tree may at the same time carry buds, blossoms, and ripe fruits.

3. **Barometric Pressure.**—Annual barometric fluctuations are slight, even on continents. The diurnal variation of the barometer is so regular and so marked that the time of day can be told within fifteen minutes if the reading of the barometer be known.

The effects on mankind of the slighter variations of atmospheric pressure are, as Castellani points out, quite unknown and unstudied. It is possible that they are without effect, because they decrease with altitude in the same ratio in which the pressure diminishes, but without producing any obvious effect from a climatic point of view.

The mean pressure, therefore, is not the same at similar altitudes in the tropics and in temperate climates, but somewhat higher.

4. **Winds.**—Two conditions prevail—viz., (1) Calms; (2) trade winds.

(1) *Calms.*—Where pressure gradients are weakest—that is, along the barometric equator—is a belt characterized by long periods of complete calm, called by sailors the "doldrums."

(2) *Trade Winds.*—In striking contrast to the doldrums are the easterly trade winds, blowing between the tropical high-pressure belts and the equatorial belt

of low pressure. These supply the high-pressure belts with a constant flow of warm air, containing a large amount of water vapour evaporated from the oceans. This saturated air needs only a comparatively high temperature to produce condensation and an abundant rainfall.

The trade winds blow over nearly half the earth's surface, and add greatly to the uniformity of tropical climates. They have long been favourite sailing routes, because of the infrequency of storms, the brightness of their skies, and the freshness of the air, all of which are in pleasant contrast with the muggy and oppressive calms of the equatorial belt.

These winds, called in the rainy season the "monsoons," control the season changes of tropical lands.

5. **Rains.**—The most important climatic phenomenon of the year in the tropics is the rainy season, which follows as a general rule soon after the "vertical sun"—*i.e.*, when the normal trade winds give way to the equatorial belt of rains or when the summer monsoon sets in.

The tropical rainy season is by no means a period of continuous downpour, as is popularly supposed. The mornings are often fine and the air comparatively bracing, so that the "season" at some fashionable places, such as Poona, is during the "rains."

The rainfall varies enormously in the various parts of the tropics and subtropics. In India, for example, it varies from about 5 inches in Sind to 120·6 inches on the Malabar coast, 253 at Mahabaleshwar, and 600 inches at Cherrapunji in the Khasia Hills, Assam.

The amount of annual rainfall has no direct relation to humidity, but this rule does not always hold good ; for instance, Lima, on the Peruvian coast, has a very humid climate, but is almost rainless, while Karachi has a damp atmosphere but a low annual rainfall.

When the rainfall is scanty, the climate is, as a rule,

hot and dry in summer, and the range of temperature at that season very high.

6. **Storms.**—Local thunderstorms are frequent in the humid portions of the tropics. In Northern India hailstorms of great violence occur, with hailstones of such magnitude that they have caused fatal injuries.

In many districts and even in a whole province, as a result of intense heating of the surface, we have great heightening of the temperature of the air near the soil, with the result that areas of low barometric pressure are created, to counteract which air converges from all sides and takes on a circular motion round its centre. These are, in fact, miniature cyclones, and revolve in the opposite direction to the hands of a watch, the motion not being truly circular, but spiral, in such a manner that a particle carried by the wind, after circling round the centre several times, is ultimately carried to the centre of low pressure. After a period of exceptional heat and stifling calm, the still leaves of the dried-up trees are agitated by light puffs of air from various directions. Soon in the distance is seen a column of dust, and this steadily advances, bringing with it a violent, fiery wind. When it has passed and the air has again cleared, a refreshing relief of the previously intense heat is experienced. When of very small dimensions, these cyclones are known as "devils," and their form—narrow below and spreading out like a funnel above—is very sharply defined. The boundaries of the expanded upper part are indistinct, and fade gradually into the steel-grey of the surrounding glare; but below the contour of the column is wellnigh as sharp as if it was composed of solid materials, and it may sweep close along by the observer without involving him. When of larger dimensions, so that the boundary of the revolving column of dust and air is beyond the range of vision, they are known as "dust-storms," and, in spite of the temporary discomforts they cause, are gladly welcomed

on account of the relief they bring from the suffocating heat. From a hygienic point of view these storms are usually beneficial, as they clear and cool the air, but, of course, their effect is only temporary.

7. **Tropical Sunlight.**—The intensity of the light from tropical skies is trying to new-comers. The intense insolation, together with the reflection from the ground, increase the general dazzling glare, and necessitate some sort of protection. The use of blue smoked or neutral tinted glass is recommended to prevent glare and dust affecting the eyes and causing pterygium. Their use also keeps the excessive feeling of heat from striking one so forcibly. The far-famed deep blue of the tropical sky is much exaggerated. During much of the time smoke, dust, and watery vapour give the sky a pale, whitish appearance. The beauties of the tropical night have, however, *not* been over-rated. Twilight within the tropics is shorter than in higher latitudes, but the coming of night is less sudden than is generally asserted.

It is obvious that sunlight in equatorial and sub-equatorial regions must be more potent than that of more temperate zones; for not only does the perpendicular course of the rays make the intervening protective layer of the atmosphere relatively thinner, but it also results in a greater intensity of illumination for any exposed area. The actual existence of this greater power is readily shown by measurements of chemical activity of tropical sunlight as compared with that of colder latitudes, and, possibly as a result of such experiments, the idea has been prevalent that the harmful effect of sunlight is primarily due to the chemically active (actinic) rays. It was because of this idea that orange-coloured underwear was tried on soldiers in the Philippines, an experiment which, as is shown in Chapter V., was unsuccessful. The other view, that it is the infra-red heat rays that are the most harmful, is held by Aron,

and he advances experimental evidence in its support (*Philippine Journal of Science*).

The sun's rays, extending from the infra-red to the ultra-violet, may be divided into the following groups—viz.: (1) Long red heat rays; (2) yellow light rays; and (3) short blue-violet and ultra-violet chemical rays.

These are much influenced by latitude, longitude, altitude, and varying local meteorological conditions.

The deleterious influence of tropical sunlight is due to the long heat waves rather than to the short chemical waves.

The action of the chemical or blue-violet rays is considerable as compared with light (yellow) or heat (red) rays, and they appear to have, first, a stimulating and beneficial influence, and, secondly, a harmful influence. Their action is very complex, but mainly that of an excitation of the nervous system. An example of the beneficial influence is the feeling of "well-being" experienced on a bright, sunny day, compared with the depression felt on a dark, cloudy day.

Chemical rays can kill bacteria. It is the middle third of the ultra-violet portion of the spectrum which causes these bactericidal effects.

Bernard and Morgan found that the ultra-violet rays are the active agents in producing sunburn. The dermatitis caused by strong electric light is identical with that caused by intense sunlight.

Ordinarily the only change in the skin produced by tropical skies is the deposit of the yellowish-brown pigment so well known in tropical residents, but when the action is intense an exudation appears, which may be sero-fibrinous, cellular, or bloody, while the depth to which these changes may extend depends upon the intensity of the light. The epithelium becomes swollen, bullæ may form, and the connective tissue of the dermis be swollen.

CHRONIC SKIN IRRITATION.—The chronic effects produced on the skin by the chemical energy of light are :

(1) Pigmentation.
(2) Vascular modification.
(3) Disease.

(1) The pigmentation of the epidermis is important. It is derived from

(1) The hæmoglobin of the blood.
(2) The cells of the epidermis.

(2) *Vascular Modification.*—Associated with pigmentation, Castellani says there is said to be a persistent dilatation of the vessels and capillaries of the skin, and it is stated that hair and nails grow more rapidly in the tropics than in the temperate zone. Light in general is believed to have an effect upon the blood, which absorbs the violet and ultra-violet rays, and the red corpuscles under these influences probably absorb more oxygen.

(3) *Disease.*—The irritating effect of light is believed to play a part in the etiology of Kaposi's disease.

Woodruffe draws attention to the almost constant neurasthenia of white men in the tropics, among whom, he says, insanity is more common than in temperate zones. Tropical amnesia, or loss of memory, is so prevalent that it gets special names in various places—*e.g.*, in West Africa it is called "coast memory," and in India "Punjab head" and "Madras muddle." The midday siesta is useful in preventing neurasthenia.

The Medical Research Council have appointed (February, 1922) a committee to advise on the promotion of research, with a view to the investigation of the effects of sunlight and other forms of light on the human body in health and disease.

The effects of sunlight on human beings may be summarized as follows: The normal human surface temperature ranges from 90° to 92° F., but on exposure

to sunlight it rises rapidly to 96° or 97° F. Further exposure results, not in a further rise, but in an actual drop of $\frac{1}{2}$° or 1°, coinciding more or less closely with the appearance of perspiration. With muscular exertion this fall is both greater and more rapid. Coloured individuals do not attain as high superficial temperatures as white men, although, from the greater absorptive powers of pigmented skin, the reverse would be expected. This is held to be due to the earlier onset of perspiration, possibly occasioned in part by the greater absorption. Coloured individuals can expose themselves to tropical skies without any danger of the painful solar dermatitis to which white men are subject.

Acton dissents from Aron's view, and holds that the pigment cells (melanoblasts) form a protective filter-screen for the cutis vera, and protect the vessels, etc. Although absorption of heat may be greater for the coloured skins, it is counterbalanced by the larger and more numerous sweat glands, which extract heat by evaporation.

If possible, travelling and muscular exertion should be done in the early morning or late afternoon, and avoided in the middle of the day, when a siesta is most beneficial.

8. **Altitude.**—Mankind lives and forms permanent habitations in Tibet over 4,900 metres above sea-level, and in the Bolivian province of Chichas people live at an altitude of 5,000 metres.

Hahn, quoting Poppig and Reck, states that natives living on the high Andean plateaus suffer from certain disagreeable effects, but Castellani cannot ascertain what they mean exactly by this expression.

In the tropics the low country possesses the true tropical climate, whilst in tropical mountains every variety of climate may be found.

Altitude is important chiefly because of its effect in tempering the heat of the lowlands, especially at night, and in providing cool stations during the hottest months,

which provide not only sites for sanatoria for the treatment of persons convalescent from lowland complaints, but grateful retreats from the heat, humidity, and insect pests of the plains.

9. **Physiological Effects of Tropical Residence.**—The continuous moist heat of the tropics renders the tropical resident very sensitive to slight temperature changes, which are readily borne in drier climates. A fall of the thermometer to within a few degrees of 70° seems to some tropical natives almost unbearable cold, and certain African tribes sleep on clay banks heated inside by fires, although the mean temperature of the coldest month is over 70°. The tonic effect of a cold winter is lacking, and after prolonged residence energetic physical and mental activity is often difficult and not infrequently distasteful.

The effects of prolonged tropical residence may be summarized as follows :

(1) *Body Temperature.*—Careful observers have failed to show any change in the body temperature of normal individuals either during passage to and from or during residence in the tropics.

There is no difference in temperature between well-nourished, healthy natives and Europeans, if allowance is made for individual and seasonal differences and the effects of exercise and clothing.

(2) *Respiration.*—Rattray studied very fully the influence of tropical climates on respiration. His results may be summarized by saying that the vascularity of the lungs is reduced by 23 fluid ounces, and, owing to the diminished number of respirations, 7·5 per cent. less air is used daily, 1·1 ounces less carbon, and 4·5 per cent. less aqueous vapour.

(3) *Circulation.*—Castellani has shown that in Europeans coming to the tropics the pulse-rate is occasionally slightly increased. This disappears after acclimatization, and the pulse-rate becomes the same as in the temperate zones.

It has been stated that in natives of the tropics the pulse is quicker than in the inhabitants of the temperate zones, but further investigation has failed to confirm this view.

(4) *Blood.*—Mitchell, from experience in the Persian Gulf, considers that damp heat of itself produces anæmia, but Strong believes that the pallor noted in some tropical residents is not due to deficiency in hæmoglobin, but to pigment deposited in the epidermis, which becomes partially opaque to red light. When more pigment is deposited the skin becomes yellow-brown (Castellani).

(5) *Digestion.*—There is often less appetite, less desire for animal food, and greater demand for spiced articles of diet, showing a tendency to diminished digestive power ; but Castellani is convinced that tropical hyperæmia of the liver other than alcoholic is a myth.

The danger of constipation in tropical climates with low humidity is well known in places like Ceylon. The necessity of imbibing daily a sufficiency of water to combat the loss of moisture from the skin hardly needs emphasis, except to women, who, both at home and abroad, often drink too little. This tendency to constipation in healthy people in very hot climates is often aggravated by difficulty in obtaining fresh vegetables and fruits during the driest times of the year.

(6) *Nervous System.*—Vital activity is increased with a higher temperature up to a certain point, after which the functional activity of the cells of the nervous system becomes markedly depressed. A great deal of mental and physical work can be done by Europeans in the tropics if the bodily health is maintained, but the depression of the nervous system, combined with the effect of the actinic rays of the sun, may result in weakening the control of the higher centres over the lower, thus inducing fits of passion caused by trivial incidents and outbursts of what Plehn calls *"tropical fury"* (*Tropenkohler*). Castellani points out

this is seen not only in Europeans, but also in natives, who are apt to do violent deeds under the impulse of unreasoning anger.

(7) *Urinary System.*—Urine is diminished in quantity on account of diminution not merely of water, but also of solids, including urea and chlorides, and Lawson says the pigments are increased.

(8) *Generative Organs.*—The generative organs act more vigorously in the tropics, but venereal excess is distinctly more deleterious than in the temperate zone.

Menstruation begins about one year earlier in Europeans living in the tropics, and in native girls in the eleventh or twelfth year. The early menstruation of Indians may be associated with child-marriage rather than climate. Puberty in boys appears earlier than in temperate climates.

The climacteric is a most trying time for the European woman in the tropics, and tends to produce neurasthenia. Authorities are undecided as to the fertility of Europeans in the tropical zone, but evidence is increasing that it greatly decreases after the second or third generation. Abortion is said to be more common in Europeans than in the temperate zone; it is also claimed that post-partum hæmorrhage is more frequent, but Castellani holds that these statements require careful investigation before being accepted.

(9) *Growth.*—Rattray made observations on the weight and growth of forty-eight naval cadets, aged from fourteen and a half to seventeen years, under four successive changes of climate during a voyage to the tropics. He considered that they grew too rapidly and lost weight considerably in the tropics, and that their strength and health were impaired by the heat.

These conclusions of Rattray's are of the greatest importance; Castellani claims that they show clearly the *necessity of* sending European children as soon as

possible to live in the temperate zone, not merely for education, but for their health.

(10) *Skin.*—The cutaneous system in damp tropical regions is flushed with blood, and often covered with visible sweat, which is apparently suitable for the growth of fungi.

In dry, hot climates the skin is liable to become inflamed and cracked in persons who possess few layers of horny cells.

In women who have resided for some time in the dry parts of the tropics the hair is apt to fall out.

Acclimatization.

In his "Asia and Europe," Meredith Townsend wrote: "It is probably much more possible for white men to colonize a tropical country than is imagined, especially if the colony was so organized that sanitary laws could be enforced from the very first"; and it is true that the basis of the largest proportion of illness and death in the tropics is bad sanitation, and not climatic influences. Sambon considered that if proper sanitary and other measures against disease were introduced, care taken with regard to food, drink, excessive heat, and the rays of the sun, there is no reason why the European should not live healthily; but experience shows that a uniformly damp, hot climate, endured for years, diminishes resistance against disease, and has a markedly deleterious effect on the nervous system, whilst fertility decreases after the second or third generation. Colonization of tropical highlands, such as some parts of British East Africa, by a European race may be possible, but in those regions prolonged residence produces changes in the nervous system of the second and subsequent generations, even if it does not do so in the first.

Tropical climates unquestionably affect the health of young Europeans, and Caddy considers that the European *is unable to rear strong*, healthy children in India. Even

those who are sent home when four or five years old are not so fine physically as their parents, owing to the debilitating influences of the tropical climate at an important growing period.

Acclimatization is undoubtedly attainable by healthy Europeans in the tropics, but colonization of the low-lying regions by a white race is regarded as impossible by all modern authorities.

Sir Frederick Lugard is not enthusiastic as to the prospects of white settlements, even on the tropical tablelands. He says: "The altitude creates a sub-tropical or even a temperate climate apparently well suited to the white races. It has not yet, however, been conclusively established that European children can grow to maturity in such conditions, and many consider that the altitude which creates the climate induces a tendency to nervous excitement and tension. . . . The presence of an indigenous native population, which is available for the unskilled and menial work, militates against true colonial development. . . . White and coloured labour have not yet learned to work side by side on equal terms in our dependencies, and the attempt has hitherto resulted in the demoralization of both."

CHAPTER II

AIR AND VENTILATION

To understand the subject it is necessary to know:

1. The constituents of the atmosphere.
2. The chief sources of its impurity.
3. The amount of air space necessary.
4. Nature's agents for purifying the air.
5. Our artificial means of supplying the individual with fresh air.
6. The dangers of impure air.

1. **The Constituents of the Air.**—*Constant:*

In 100 volumes in all parts of the world—

(1) Carbonic acid (CO_2), 0·03 parts.

(2) Oxygen, 20·94 parts.

(3) Nitrogen, including helium, neon, krypton, and zenon, 78·09 parts.

(4) Water in gaseous form, 1·4.

(5) Argon, 0·94 parts.

Occasional:

(1) Ozone.
(2) Ammonia.
(3) Marsh gas.
(4) Sulphuretted hydrogen in towns.
(5) Carbonic oxide.
(6) Sulphurous acid.
(7) Nitric acid.

2. **The Chief Sources of Impurity of the Air:**

(1) Products of respiration of men and animals.
(2) Products of combustion.
(3) Products of decomposition.
(4) Dust.
(5) Bacteria.

(1) *Products of Respiration.*—Respiration adds to the air the following:

(*a*) Water. (*c*) Bacteria.
(*b*) Carbon dioxide. (*d*) Dead tissues.

The proportion of the last two added to the air varies greatly, but the quantity of carbon dioxide added is comparatively constant. In round numbers, 4 per cent. of oxygen is abstracted from the air in the lungs, whilst 4 per cent. of carbon dioxide is added to it.

Expired air is usually saturated with watery vapour, but the exact amount of water added varies with the degree of saturation which obtains in the air breathed.

As a round figure, it may be stated that about half a pint of water is given off by the human lungs and about a pint by the skin in twenty-four hours.

In health expired air contains few microbes, but much organic matter. The organic matter diffuses sluggishly through the air of a room, and is destroyed slowly by fresh air. It promotes the growth of micro-organisms, and rapidly taints milk, meat, and other foods in contact with it.

The average adult gives off about half a cubic foot of carbon dioxide per hour, and oxen and horses about three times that amount, plus an indefinite amount of organic matter, so that it will readily be grasped how indescribably foul the air of tropical huts can become from these physical changes when half a dozen human beings and several animals are herded together in one small unventilated room in the still atmosphere of the equatorial belt.

Kenwood says the repeated inhalation of air fouled by human beings tends to the production of a lowered state of health, and promotes the onset of disease. Much importance has been attached to the presence of carbonic oxide in air, but recent experiments have demonstrated that it is to the physical changes and not to the increase in this gas that the impure air of over-

crowded rooms owes it harmful effects. It has been found that even with as much as 1·7 per cent. of CO_2 no injurious property of air in crowded rooms could be demonstrated so long as the temperature and humidity remained low. Beyond certain limits there appeared both in normal and diseased persons feelings of drowsiness, headache, oppression, lassitude, giddiness, and nausea, but these symptoms could be relieved at once simply by reducing the temperature and humidity of the air to normal. They are attributed to "heat retention," by which term is meant the partial abeyance of the normal ability to lose heat by radiation and evaporation from the surface of the skin and from the lungs.

The precise point at which the effect of air temperature on humidity is reflected by a definite rise in body temperature is 88° F. in a still atmosphere and 93° F. in moving air.

(2) *Products of Combustion.*—The chief products of combustion are: (*a*) Carbon dioxide, (*b*) carbon monoxide, (*c*) sulphur compounds, (*d*) water, and (*e*) fine particles of matter.

In the tropics fuel generally consists of wood, and kerosine oil is the chief illuminant. Burning wood yields few of the sulphur compounds.

(3) *Products of Decomposition.*—The chief practical point in this connection is that decomposing vegetation produces the poisonous and inflammable gases H_2S and CH_4, so that the heaps of rotten leaves, etc., which are sometimes to be found outside a bedroom in the tropics are things to be avoided.

Sulphuretted hydrogen may occur not only in marshes, but in and near excavations, in collections of refuse or decaying vegetable matter, and in other waste heaps.

The inhalation of this gas is frequently followed by marked poisonous results. An atmosphere containing *1 part in 7,000* parts of air is dangerous to human life, *whilst air containing* 1 to 2 parts per thousand kills in *a few minutes.* When only minute quantities are

present, giddiness, headache, and general depression are produced.*

(4) *Household Dust.*—This is a source of impurity of the greatest interest in the tropics. The following ingredients may be found by microscopical examination of ordinary dust: (*a*) Fragments of charcoal; (*b*) fragments of cotton and other fabrics; (*c*) fragments of skin; (*d*) fragments of insects; (*e*) fragments of hay or straw; (*f*) dried sputum; (*g*) dried fragments of excrement; (*h*) bacteria anchored to all these various particles of matter.

The harmless-looking motes which we see dancing in the sunshine are, therefore, very frequently as dangerous as cordite, and constitute not only an undesirable but positively disgusting mixture.

Rooms should therefore be constructed so as to facilitate the removal of dust, as it consists largely of organic refuse, sometimes more or less putrescent, and its presence in the air assists in the production of the low state of health so common in the occupants of dirty, overcrowded houses.

Lessons in the use of a simple cloth for dusting, on the value of wet sawdust or tea-leaves before sweeping out rooms, and in vacuum-cleaning, would be a useful addition to the elementary education of tropical scholars.

The vacuum-cleaning process is now largely used in Europe for removing dust and deposits from rooms. It consists of an apparatus which produces a vacuum in a chamber to which is connected a flexible pipe. The nozzle end of this pipe is applied to articles or walls to be cleaned, and the dust is drawn by suction into the receiving chamber with very little disturbance of the contents of the room. Carpets and hangings are very effectually "dusted" by this process, and it deserves attention in the tropics.

(5) *Bacteria in Air.*—Bacteria in air vary in number and *species*, according to certain external conditions

* *Vide* Chapter I., p. 5.

such as the pollution of the air, the dampness of surrounding surfaces, gravity, and various seasonal and climatic conditions.

Haldane and others have confirmed, by the examination of air from numerous sources, Tyndall's statement that dust carries microbes, and that, other things being equal, dusty air contains more bacteria than dust-free air. In the open jungle, on mountain-tops, and at sea, few bacteria are present; but in crowded Indian bazaars they abound in countless myriads. A polluted or dusty atmosphere generally contains many bacteria and much carbonic acid, but there seems to be no direct relation between them. An atmosphere may be offensive and yet comparatively free from bacteria, as in the case of sewer gas and railway tunnels. The presence or absence of an offensive odour, therefore, must not be regarded as a criterion of the purity of the atmosphere.

Air over sandy soil contains more bacteria, as a rule, than that over damp clay soils. Rain diminishes the number of organisms in the air. It has also been proved that air saturated with moisture is almost germ-free. Hence the comparative absence of bacteria in expired air in ordinary quiet respiration, though in the act of coughing, sneezing, or shouting, organisms may be present. The same principle applies in sewers, the air of which frequently contains fewer organisms than that of the outside air. This is also the explanation of the retention of the tubercle bacillus in sputum, and the typhoid bacillus in dejecta, when these materials remain moist.

The seasonal maximum of bacteria in the open air seems to occur about midsummer, and the minimum about the middle of winter; but in hospital wards and houses the reverse occurs. Air currents and winds, and of course rain, exert a marked influence. As already pointed out in Chapter I., sunlight in tropical lands possesses great germicidal powers, and is a potent agent in reducing the number of air organisms.

Apart from definite pathogenic bacteria, the number of harmless organisms in air does not appear to be very material. The number of germs per litre of air is more an index of cleanliness and absence of dust than of efficient ventilation and the avoidance of respiratory impurity.

The variety of microbes found in the air is considerable, and for the most part they are harmless to man. They are not due to respiration, and whilst many may be due to uncleanly persons or clothing, they are mainly derived from the walls, ceiling, and floor of the room itself, especially if these are porous and absorbent, as is the case in most rooms in the tropics. They do, however, include putrefactive, suppurative, and intestinal organisms, and the specific germs of disease. The bacilli of tubercle, typhoid fever, and other diseases have, under favourable conditions, been isolated from air, and Gordon has described an "air streptococcus" and a "skin staphylococcus" always associated with filth and human pollution.

The injurious effects due to the breathing of air vitiated by human respiration were believed to be due to organic matters contained in expired air. It was also thought that organic matters suspended in the air, consisting of small particles of epithelium and fatty matters from the mouth, and organic vapour from the lungs, and air-passages, were poisonous when rebreathed. The experiments of Haldane and Lorrain Smith tend to show that there are no volatile organic poisons in expired air; and there is no definite proof that the presence of organic matter in respired air indicates that it is derived from the lungs. Parasitic skin disease may spread through the air, for sporules and the mycelia of *Trichophyton tonsurans* and *Achorion Schönleinii* have been found floating in the atmosphere of wards occupied by patients suffering from diseases of the skin.

The zymotic diseases generally are more prevalent amongst *overcrowded* populations. This may be accounted for by the ease with which contagion can pass

from the sick to the healthy; for air vitiated by the ordinary products of respiration of a healthy person may induce illness, but cannot be productive of a specific disease.

Kenwood thinks there is some unidentified constituent of air vitiated by human respiration and transpiration which is responsible for the injurious action of such air upon health. Whether this unknown substance is present in expired air or given off from other parts of the body is uncertain. None of the points to which such attention has been devoted by hygienists—viz., (1) excess of CO_2; (2) deficiency of oxygen; (3) absence of ozone; (4) a raised temperature; (5) excess of moisture; or (6) the presence in the air of non-pathogenic micro-organisms from the air-passages—taken either singly or in combination, appear able to give rise to those far-reaching effects that the continued respiration of foul atmospheres is known to produce. Kenwood concludes that whilst nothing of any importance is given off to the air by human respiration and transpiration, yet the air by such means is deprived of some vital element with which we are unacquainted, and without which the highest state of bodily health and efficiency cannot be maintained.

3. **The Amount of Air Space Necessary.**—This will depend on the purpose for which the room is to be used. More space is, for instance, required in a factory than in a dwelling-place.

For ordinary living-rooms—in Europe, at least—1,000 cubic feet of space is allowed for each person occupying the room—*i.e.*, a space 10 feet long, 10 feet wide, and 10 feet high. In calculating the cubic space of a room, the cubic space occupied by furniture must be deducted, and an allowance must be made for the number of lamps generally used. The more lamps used, the larger must be the cubic space allowed for each person ordinarily occupying the room, and it may be taken as a rough average that every kerosene-oil lamp burning in a room pollutes the air to the same extent as seven adults.

In buildings which are only occasionally used, such as churches, theatres, schoolrooms, and the like, it is generally quite impossible to allow sufficient cubic space for the large number of persons assembling there. To make up for this, ventilation should be as free as possible. In hospitals a much larger cubic space and the freest ventilation are particularly necessary. In factories, shops, and offices particular attention must be given to providing as much cubic space and free ventilation as possible.

The Factory and Workshops Acts of 1901 and 1907, which are, of course, not applicable outside the United Kingdom, enact that there must be at least 250 cubic feet of air space for each worker. The air space of each room must be stated in a notice affixed in the works.

A much larger air space is required in certain dangerous trades—*e.g.*, in match factories, in which yellow phosphorus is used, the minimum is 400 cubic feet, and height above 14 feet is not to be counted; in engineering works exemption from routine annual limewashing is allowed if the air space be 2,500 cubic feet per head.

For general purposes of ventilation, all height of rooms above 10 feet may be disregarded, but in the tropics the height from floor to roof should be 15 feet or more, for reasons to be indicated later. The extra height must not, however, lead to any reduction in the amount of the floor space. One thousand cubic feet of fresh air contains 0·4 cubic foot of carbonic acid, and a man gives off 0·6 cubic foot of CO_2 per hour; Wilson Jameson found that when the CO_2 percentage exceeds 0·1 in occupied army huts there was usually a sensation of stuffiness, and concluded that *sense of impressions* in conjunction with the percentage of CO_2 constitutes satisfactory means of forming an opinion as to the state of the air. Three thousand cubic feet of air per hour is *required to maintain* a reasonable standard of purity *measured in this* way.

For instance, if six people are living in a room, to give the space recommended in Europe it would require to be 30 feet long and 20 feet broad and 15 feet high, and the air would have to be changed thrice every hour.

In native houses in the tropics accommodation to this extent is utterly out of the question, so fortunately it is possible in a damp, warm climate to change the air oftener than three times every hour. In cold climates, such as that of England, or India in the cold season, this is difficult to do, as it is found that if the air is changed more than thrice an hour the room becomes too cold and draughty, and people are apt to "catch cold," as the effect of a "thorough draught" is to cause too much stimulation of the cutaneous vessels, which contract and drive the blood to the internal organs, leaving the skin cold, whilst the internal organs are unduly congested. Chills are thus induced which may have serious results and be the precursors of illness.

In temperate climates a chill usually results in the invasion of the mucous membrane of the upper air-passages, but in the tropics the result of chill is too often the invasion of some lethal intestinal organism; but in most parts of the tropics the "draughts" produced by the free perflation of air necessary to attain the amount of air changes necessary have no prejudicial effects whatever.

4. **Nature's Agents for Purifying the Air.**—These are:

(1) Rain.
(2) The action of sunlight.
(3) The action of plants.
(4) Winds.
(5) Diffusion of gases.
(6) Differences of temperature.

(1) *Rain.*—Rain is simply a mechanical purifier; it washes the air. As it falls it removes all suspended *organic* impurities, and absorbs some of its harmful *gases.*

(2) *The Action of Sunlight.*—Sunlight has the power of killing germs in the air.

(3) *The Action of Plants.*—In the presence of sunlight plants absorb carbonic acid from the air and give off oxygen.

(4) *Winds.*—Winds tend to distribute the air, and thus, by mixing the gases, produce uniformity of composition. They are powerful ventilating agents.

(5) *Diffusion of Gases.*—All gases tend to mix with one another, in accordance with Graham's law that the diffusibility of any two gases varies inversely as the square root of their density.

The atmosphere, being a mechanical mixture of gases, is subject to this law, and tends, therefore, to uniformity of composition. The gases, vapours, and animal impurities breathed out by animals mix readily with the air and are diluted, and the more air they are mixed with the less harmful they are.

(6) *Differences of Temperature in Air.*—Warm air is lighter than cold; therefore it ascends, and is replaced by the heavier cold air. The warm air and bad gases in an inhabited room ascend toward the ceiling. If there is an opening at the top of the room, the foul air goes out by it, and is thus got rid of. If there is no such opening, however, the bad air gets cooler, becomes heavy, and descends, and the inhabitants are obliged to inhale it once more. It follows, then, that all houses should have openings in the upper part of the room to let out the foul air. In the tropics exit of foul air is best assured by having small windows placed near the roof.

Under this heading comes *Natural Ventilation.* This is effected by the last three agents—viz., (*a*) winds, (*b*) diffusion of gases, and (*c*) difference in temperature.

(*a*) *Winds.*—Ventilation by perflation, or "flowing through," is the chief means of ventilation in the tropics. Houses should have windows and door nearly facing one another.

Perflation, however, cannot alone be exclusively relied on, as the winds change very frequently.

In most better-class tropical houses there are so many doors and windows that there is no risk of bad ventilation if they are left open. The covering of doors and windows with *chics* or *jhilmils* to keep out glare, heat, flies, etc., need not interfere seriously with the ventilation.

In hot weather windows and doors should all be left open at night. In the daytime air finds its way in through the *chics* covering the doors.

(*b*) *Diffusion of Gases.*—Punkahs and electric fans do not increase the purity of the air. They only move the air in the room, and do not to any extent draw in the outside pure air or drive foul air out of the room.

In hot weather there is often little difference between the temperature of the air inside and outside of the house, and so there will be little or no exchange of air going on. It is thus all the more necessary that the rooms should be large, and that the doors and windows should be left open as much as possible. The difficulty is that by the latter procedure the hot outside air enters the rooms, but *khus-khus* tatties* will cool it where the air is dry or hot winds frequent. In moderately hot weather doors and windows should be left open day and night as much as possible. The heat will do far less harm than breathing poisonous air.

If the air is stagnant and still, the moisture-laden emanations from the body are imprisoned and entangled by the clothing, and a humid layer of foul air hinders further evaporation; while if the air around the body can be sufficiently removed, evaporation continues its beneficent work of throwing off waste products and regulating the body temperature. Doubtless this circumstance explains the sanitary effect of electric fans and punkahs, which, as we have seen, do not subserve ventilation, but simply keep the air in motion.

* *Vide* Chapter VI., p. 98.

The huts of the poorer classes are generally very badly ventilated. There are no outlets for smoke or foul air, and, where they exist, they are usually tightly closed up in the colder season.

(*c*) *Difference in Temperature of Pure and Foul Air.*—As hot air ascends, a space for ventilation along the topmost ridge of the roof—the so-called "ridge ventilation"—should be provided, or a space left between the top of the walls and the roof.

The latter is a favourite device for securing this method of natural ventilation in tropical barracks.

A staircase should be well ventilated by a large rain-proof opening in the roof, as the staircase not only receives foul air from the rooms, but feeds them with air.

5. **Artificial Means of Supplying the Individual with Fresh Air.**—This embraces the method of artificial ventilation. This falls under two headings—viz.:

(1) The *plenum* method, in which the fresh air is driven into rooms by revolving fans.

(2) The *vacuum* method, in which the foul air is extracted by heated outlet shafts, steam jets, or fans.

Heat is the motive power generally used for extraction.

Ordinary fireplaces, chimneys, and ventilating gas-lights are familiar examples of the latter method.

A variety of *plenum* method is familiar in India in the form of an artificial ventilator known as the "thermantidote." It propels a stream of fresh cooled air into the room, and thus cools and ventilates it. The apparatus must be used so that no draught or current of air from it is felt, and, where possible, it should be placed in a room opening out of the room in use, and the cool air thus allowed to gradually mix with that of the room which is being occupied.

6. **Dangers of Impure Air.**—Crowding in a common atmosphere has long been known to be disastrous in cerebro-spinal meningitis, erysipelas, diphtheria, influenza, and other maladies, both as regards transmis-

sion of infection, intensification of type, and retardation of recovery. Ventilation has greatly lessened phthisis in barracks and other institutions. The success of the open-air treatment in sanatoria for phthisis has the same significance. It is evident that all diseases in which the breath is infectious must be more readily transmissible when the expired air is rebreathed in a concentrated form.

There is abundant evidence of the gain in comfort, general health, and longevity under conditions of adequate fresh-air supply, and, conversely, of much disability from sickness of all kinds, and high death-rates, amongst those whose lives are largely spent in ill-ventilated rooms.

The feeble health of the tropical resident is largely due to the way in which he shuts himself up in small unventilated rooms, and then covers his face up with a sheet or blanket.

The debilitating effects produced by respiring impure air are undoubtedly augmented when such air is much raised in temperature, and the tendency to an increased output of foul-smelling volatile products from the bodies of the occupants of a room is materially increased by a high temperature and an atmosphere approaching saturation from the presence of moisture given off in the breath. The temperature of the air or its relative humidity are seldom sufficiently raised by the presence of the occupants of a room to exert any noticeable effects, except where the ventilation is very deficient.

Recent physiological research places special emphasis on movements of masses of air at somewhat different temperatures as being essential to the continuous stimulation of the surface cutaneous nerves of the body, on which health and comfort so largely depend. The cooling power of the open air stimulates metabolism and cures disease. It does not matter a great deal whether the sun is shining or not.

CHAPTER III

WATER AND WATER-SUPPLIES IN THE TROPICS

A MAN must not throw any impure substance into water (*Institute of Vishnu*). All the world over man derives his water-supply directly or indirectly from the rainfall. Water, as it condenses in the clouds from the gaseous state, is absolutely pure, but by the time that it reaches the surface of the earth in the form of rain it has become impure. Rain, as we have seen, is a purifier of the air, and in performing this service to man it becomes itself impure. It washes various undesirable gases, and obnoxious solids in the form of dust, out of the air, and either sinks into the soil or flows along its surface in streams.

In the tropics pure water for drinking purposes is not easy to obtain. The reason for this difficulty is mainly due to the pollution to which the water is subjected by the customs of the people, and it is largely owing to this pollution that diseases caused by micro-organisms and helminths are so rife. In warm climates disease germs and parasites exist in water in far greater variety and numbers than in the temperate zone, where the conditions are not so favourable to their growth and development. The drinking of impure water is liable to produce enteric fever, diarrhœa, dysentery, dyspepsia, cholera, and goitre ; in the tropics the risk of these diseases is greatly increased. In hot climates even *the external* use of bad water for bathing purpos

may cause Oriental sore, guinea-worm infection, bilharziasis, and other maladies.

Tropical like temperate water-supplies are obtained from six sources, which, according to their origin, are known as:

1. Rain water.
2. Upland surface water—*i.e.*, water running down hills in small streams to natural or artificially made lakes.
3. Ordinary surface water from cultivated land, such as landsprings, streams, and ponds.
4. River water.
5. Ground water from wells and springs.
6. Distilled water.

Comparison of Waters derived from Different Sources.

The Rivers Pollution Commissioners classify the qualities of these waters as follows:

In respect of wholesomeness, palatability, and general fitness for drinking and cooking—

1. Wholesome.	(*a*) Spring water. (*b*) Deep well water.	Very palatable.
2. Suspicious.	(*c*) Upland surface water. (*d*) Stored rain water.	Moderately palatable.
	(*e*) Ordinary surface water from cultivated land. (*f*) River water to which sewage water gains access. (*g*) Shallow well water.	

In respect to softness they grade them as follows:

(*a*) Rain water.
(*b*) Upland surface water.
(*c*) Surface water from cultivated lands.
(*d*) Polluted river water.
(*e*) Spring water.
(*f*) Deep well water.
(*g*) Shallow well water.

From the above it will be seen that the comparatively hard waters, derived from springs and deep wells, are the safest for drinking purposes, and the interests of the trading community are thus opposed to those of the householder.

1. **Rain Water.**—As a source of supply, rain largely concerns us in the tropics; in places where the rainfall is heavy and the springs are brackish it forms our chief stand-by.

In warm countries, where the dust-storms referred to in Chapter I. are frequent, the roofs of the houses are generally polluted with animal matter from the excrement of birds, dust from the roads, and the eggs of insects. These pollutions washed into tanks give the water an unpleasant taste, and in some instances cause disease. It is desirable, therefore, that as far as possible impurities from the roof shall be prevented from gaining access to the tank. With this object contrivances have been made which reject the first washings off the roof, and afterwards direct the flow into the storage tanks.

Roberts's separator is one of the most ingenious of these machines. It is constructed in sizes which bear a ratio to the superficies of the roof area, and is so arranged that, when a sufficient amount of rain has fallen to cleanse the roof, the water first collected is tilted into the waste channel, and the remainder directed into the collecting channel and reservoir.

The same inventor has devised an apparatus whereby pure water may be obtained from the roofs of cottages and houses *too small* for the use of the separator. The *dirty water which* first comes from the roof during a

spell of rain is rejected, whilst the clean water which falls later is directed into a storage tank, thus preventing any mixture of the clean and unclean water.

Rain and other soft water possesses the disadvantage of ability to dissolve lead, iron, or zinc if left in contact with these metals. Consequently cisterns of lead, iron, or zinc, and even galvanized iron in some cases, should not be used to store soft water.

2. **Upland Surface Waters.**—In hilly districts the water which flows off the hills in the form of rivulets or streamlets can be collected and stored.

Under these headings are included natural lakes in mountainous districts. In their comparative freedom from mineral matters these waters approach more nearly the composition of rain water than water derived from any other source.

A great number of places in the tropics obtain their supply from sources of this kind, which are generally good, as highland districts are usually sparsely populated, and the land is accordingly poorly cultivated, so that the risk of sewage contamination is slight. The catchment area should be carefully protected from pollution.

3. **Ordinary Surface Water.**—This must always be regarded as dangerous, as the presence of sewage is wellnigh certain. Ponds and tanks constitute a particularly dangerous source of water-supply, which, unfortunately, is the only one obtainable in many parts of the tropics.

The habits of the native render this source peculiarly dangerous, more especially in the vicinity of towns and villages, apart from its liability to gross pollution at any time.

4. **River Waters.**—Rivers are constantly liable to pollution by men and animals. If it were not for the beneficent purifying work of oxygen, rivers in the tropics *would soon* become little more than open sewers; but

fortunately purifying processes go on actively in river water, and if the stream has many falls and eddies, the amount of oxygen dissolved in water is so great that a moderate amount of contamination is soon got rid of. Where considerable plant life exists, various green river plants aid by giving off active oxygen, and, moreover, when the oxygen dissolved in the water is used up, fresh oxygen is absorbed from the air. The actual germicidal value of even powerful tropical sunlight is doubtful, as the water may cut off the active rays, but it is clear that the oxidation process in rivers is started by bright sunlight, and when the stream becomes thick or muddy this process is checked or stopped. Even when this occurs, however, a purifying action still goes on, as the infusoria, amœbæ, water worms, water fleas, etc., which exist in countless numbers in certain water, live on sewage or other organic débris. Unfortunately, these purifying processes in most rivers are not sufficient to cope with the quantity of dead organic material constantly poured in from source to mouth. The value of fish as purifying agents of water is so well known as to require merely a passing reference.

5. **Ground Waters.**—The water which falls on the earth and sinks into the soil returns again for the use of man as (1) wells and (2) springs.

(1) WELLS.—To appreciate the condition of tropical wells, it must be understood that land in the neighbourhood of villages and towns in the tropics is polluted with human excrement to a degree which is almost incredible to those not conversant with Oriental conditions. Latrines may be available, but practically the whole of the male and some part of the female population prefer to go to the neighbouring fields rather than make use of any fixed structure. It is only in large cities, where fields are at a considerable distance from the house, that latrines are used to any extent, and even then a fair

proportion of the inhabitants, particularly children, simply make use of the pieces of waste land and lanes in the midst of the houses. The fæcal discharges deposited in this manner are not buried in the manner customary amongst the Jews, but simply left to the drying action of the sun and hot winds. Naturally, in rainy weather they are washed into the soil, if the latter be of a sufficiently porous nature, and yet the entire population living under these conditions almost invariably derives its water-supply from shallow wells.

Wells are divided into three varieties: (*a*) Shallow, (*b*) deep, and (*c*) artesian. The descriptive words are not used to indicate the relative depth of the wells, but to describe the water-bearing strata they tap. All shallow wells must be regarded as suspicious sources of supply, and none of them can be looked upon as safe. The health officer would be ill-advised to sanction the use of any well water on the mere ground of satisfactory laboratory analysis. At any moment pollution may occur after the passed sample has been collected, so that analysis must always be considered in conjunction with careful inspection of the source and its surroundings.

(*a*) *Shallow Wells.*—Shallow wells are those which are sunk in pervious soils, and tap the subsoil water which has percolated from the surface within its immediate vicinity.

Lakes and open reservoirs often become contaminated by algæ and other microscopic organisms, which may colour the water red or green-blue and render it turbid and offensive in smell. The odour and turbidity of the water is unpleasant, and interferes with sand filtration, but does not appear to induce any injurious effect upon the consumer. Covered reservoirs are not usually subject to the growth of algæ.

The Rivers Pollution (Sixth Report) Commission state *that in their* experience shallow wells were almost

always horribly polluted by sewage, and by animal matters of the most disgusting origin.

In the large majority of cases where shallow wells yield polluted water, this is due to defects in the construction of the wells.

The water which enters a well at a depth of 6 to 12 feet (provided there are no cracks in the stratum, especially in chalk), according to the porosity of the soil, is usually efficiently filtered and purified. Water entering at a less depth is always liable to be imperfectly purified and unsatisfactory in quality. The nearer the ground surface at which water can enter, the greater the danger of pollution.

It follows, therefore, that the upper 6 to 12 feet of the well should be water-tight, and that the top should be so finished off that no surface water can possibly gain access. The top of the well should be brought up about a foot above the ground surface, and covered with a well-fitting iron cover. Wooden covers warp and soon become useless in the tropics. The area surrounding all wells should be concreted and provided with a water channel.

Pumps should always be provided, as dipping of buckets provides endless facilities for contamination.

A radius of four times the depth of the well, or if possible 100 yards, should invariably be left clear round all wells.

(*b*) *Deep Wells.* — These are wells which pass through both the pervious surface layer and an underlying impervious stratum, and tap water which has percolated from land surface at some distance from the shaft. They are good sources of supply, but, unfortunately, comparatively rare in the tropics, as their construction is expensive.

(*c*) *Artesian Wells.*—Artesian are merely a variety of deep wells, but are far better than dug wells. They consist of iron tubes bored through the impervious

stratum until the water is reached. Like all other wells, they must be adequately protected at the surface to prevent pollution.

(2) SPRINGS.—These are generally described as land and main springs. Land springs are often due to surface depressions touching the underground water-level. When the underground water reaches its lowest level, such springs run dry quickly.

Manifestly, they receive their supply from very near the surface, and are extremely liable to organic pollution.

The classification of all springs as wholesome by the Rivers Pollution Commission is, therefore, misleading.

Main springs are, however, generally very good, but occasionally they too are doubtful sources of supply, and great care is necessary to investigate their immediate neighbourhood for surface-derived impurities.

6. **Distilled Water.**—Distillation effects a more complete purification of water than any other process, and is the means of supply to the troops and residents in rainless tracts, such as Aden, and in regions where the rainfall is scanty or where there are only salt lakes.

Distilled water is also used for the ships of H.M. Navy and large passenger steamers, not only when the ordinary store runs out, but as the routine method of supply.

Distilled water is flat and unpalatable, so that its efficient aeration is an important consideration, and should form a part of the plant for providing it on a large scale. For ordinary purposes it may be aerated by half filling an ordinary wine-bottle with the water, and then vigorously shaking, so as to cause the air to be absorbed by the water. Several makes of small domestic stills are on the market. Statements are made that distilled water is not well adapted for drinking purposes, but no physiological or clinical evidence has been *adduced in verification.*

The amount of water or other liquids required by man, over and above what he obtains in his food, is about 2 pints in temperate climates, but in the tropics a very large quantity is consumed.

Man requires water for many purposes, and the quantity which he uses varies with the locality.

The following are the minimum amounts of water required in the tropics:

Drinking purposes	½ gallon.
Cooking "	1 "
Personal ablution	5 gallons.
Clothes washing	3 "

In places like Calcutta and Peshawar the daily allowance per head is as much as 41½ gallons of filtered water; but in many tropical towns, villages, and even military cantonments, scarcity of water constitutes a hardship.

There is no doubt that the compulsory storage of water for the purposes of cooling during the hot weather is a fruitful source of pollution, and too much attention cannot be paid to it.

The ordinary Indian *surai* certainly cools water, but has the disadvantage of being difficult to clean. Moreover, it is readily passed from mouth to mouth, and is not always kept covered.

Water should be stored in glazed vessels, and these should always be kept perfectly clean and cool. Metal vessels may also be used for drinking waters, as they can be kept clean. The brass and copper lotahs which are in general use in the East amongst Hindus may subserve to keep the water pure, as experiments indicate that iron and copper in minute quantities inhibit the growth of pathogenic organisms.

The reason that glazed and not unglazed chatties should be used is that the latter take up dirt of all kinds by their pores, whilst in the former these pores are filled up, and so cannot absorb dangerous substances.

The smooth glazed surface is also much more easily kept clean than the unglazed.

Pollution of Water-Supplies.

This may occur:

1. At the source.
2. During transit.
3. During storage.

1. **Pollution at the Source.**—Every effort must be made to prevent any form of pollution in the neighbourhood of the wells, springs, or tanks from which drinking water is obtained. The question of the protection of "catchment areas" is one of the first importance to Governments and municipalities in the tropics.

In many places in the tropics it is a common practice to bathe in the tank from which the drinking water is taken, also to spit and wash the mouth in the tank or stream used for drinking purposes. The residents then collect the water quite close to the place they have just polluted for their cooking and drinking supply for the day.

2. **Pollution during Transit.**—This is another very common source of infection.

The transport of drinking water to the house is an important matter in the tropics, as even in large towns provided with modern waterworks it is only the few better-class residents who can afford pipes to their houses. The best pipe supply is usually only a street distribution. In India the water carriers employ for the conveyance of water what is called a *mashak*, which consists of the entire skin of a sheep or goat roughly cured, and carried slung across the back. This mode of transport in a leathern vessel which cannot be kept clean is sure to contaminate the water, however pure the source from which it is taken.

3. **Pollution during Storage.**—Drinking water should not be stored at all during cold weather, unless the procedure is absolutely unavoidable; but in the hot season some simple means of storage for the purpose of cooling becomes an imperative necessity.

Galvanized iron or slate cisterns are the best means of storage on a large scale, but they are usually impracticable for tropical houses on account of expense. For storing small quantities of drinking water clean glass bottles with air-tight glass stoppers, such as those in which pasteurized milk is issued, are best for use in houses, but they are costly.

All vessels used for storing water must be kept covered, so as to prevent dirt and dust from falling into the water.

The Purification of Water.

In most tropical countries we have to start with the idea that the water is bad, and endeavour to remedy the defects of the natural supply as best we can.

It often happens that, owing to a deficiency in the amount of pure water available, a town is provided with two supplies—a pure water for drinking and a less pure water for washing, trade, and municipal purposes. This is the case to some extent even in large Continental towns, such as Paris. There are circumstances, of course, in which this plan is unavoidable, but as a principle it is a bad one; for it frequently happens that the impure water is used for drinking purposes, and in this way epidemic disease is spread.

Broadly speaking, there are three methods for rendering impure water innocuous:

1. Physical—(*a*) by distillation; (*b*) by boiling.
2. Mechanical—by filtration.
3. Chemical—(*a*) by precipitation; (*b*) by use of germicides.

1. **Physical.**—(*a*) Distillation is, as we have seen, chief *means of* supplying drinking water at Aden

in other rainless regions. (*b*) Boiling presents one of our oldest and best methods of preventing the noxious effects of bad water. Combined with some simple form of clarification or filtration, if fuel is available, it is the readiest method of dealing with impure water.

Its disadvantages are—

(1) It is expensive, because fuel is required.

(2) The water becomes insipid.

(3) The water is heated, and must be cooled before use.

The first of the disadvantages is vastly the most important. The remaining two can be got over by aerating the water in the way already described, and by storing it in tightly corked bottles in an ice-chest.

2. **Mechanical.**—Purification of water on a large scale is necessary in all water derived from catchment areas containing arable land and from rivers. It is effected by (*a*) storage, (*b*) sedimentation, (*c*) filtration.

(*a*) *Storage.*—Houston states that simple storage for four weeks will eliminate 99 per cent. of disease-producing organisms from water.

(*b*) Sedimentation, already referred to as a natural means of purifying water, is effected by storing the water in a large reservoir. The action of gravity causes suspended matter, coarse and fine, to fall to the bottom, carrying with it a large proportion of the micro-organisms present in the water. The best results are obtained when the flow of water in a reservoir is sufficient to prevent stagnation, and at the same time to enable gravity to operate. Under such conditions the average number of microbes is reduced from 16,000 per cubic centimetre to numbers varying from 1,000 to 7,800.

...ation of some kind or other is a method ... existed from time immemorial, as the ancient ...s directed that water should be drunk only ...ing through cloth. Even of the crudest ...*ation* always improves the potability of a

water, and a simple device, such as barrels fitted one inside the other, with a layer of gravel, sand, and wood ashes between them, will not only clarify, but actually purify water very considerably.

Filtration of water may be by: (1) Public filtration; (2) domestic filtration.

(1) PUBLIC FILTRATION.—The principal public filters in use are: (*a*) Sand filters; (*b*) coagulant filters; (*c*) Anderson's filter.

(*a*) *Sand Filters.*—Sand filters are composed, from above downwards, of (1) a layer of sharp sand 3 feet in depth; (2) a layer of gravel or broken shell 6 inches in depth; (3) 6 inches of small boulders, large gravel, or bricks. The efficiency of filtration does not depend so much upon the total depth or composition of the filter bed, as on the rate of filtration and the formation of a zoöglœa mass on the surface of the sand. In London the depth of the water on the filter bed does not exceed 2 feet, and the rate of filtration is about 1½ gallons per square foot per hour, or 36 to 42 gallons in twenty-four hours. The efficiency of sand filtration may be gathered from the fact that the number of organisms per cubic centimetre is reduced from 16,000 in crude Thames water to numbers varying between 35 and 100.

Koch has laid down the principle that no water should be permitted to enter a service reservoir which contains more than 100 organisms per cubic centimetre, and the experiments of the Massachusetts Board of Health prove that filtration removes fully 99 per cent. of organisms, provided the sand filtration is 60 inches in depth and the rate of filtration does not exceed 2,000,000 gallons per acre per twenty-four hours.

The highest point of efficiency of a filter bed is not obtained until at least two or three days after it has commenced working, the operation being much more than a mere mechanical straining operation. The thin gelatinous film, consisting of organic matter and bacteria

which forms on the surface acts as a biological filter, arresting micro-organisms.

The life of a filter bed depends upon the character of the water to be filtered; at Peshawar, on the Indian frontier, where a very crude river water is dealt with, it is eight days. At the end of this time the filter bed is allowed to run dry, 2 inches from the top are removed, and replaced by clean sand.

(*b*) *Coagulant Filters.*—Of late years ordinary sand filtration has been found too slow for rapidly expanding communities, and has been replaced in many places by apparatus based on the principle of mechanically filtering a mixture of the water and some coagulant at high velocity through the sand. The Jewell filter, the best known of these special filters, and in use in Delhi, Naini Tal, and other Indian stations, consists of (*a*) Two tanks and a mixing tank; (*b*) a subsidence tank; (*c*) a filter proper.

(*a*) Mixing tank: In the tank the *coagulant*, which consists of a 2 per cent. solution of sulphate of alumina, is added to the raw water. The water mixed with the alumina passes to (*b*) the subsidence tank, where the use of the coagulant results in the forming of a flaky, jelly-like substance, which carries with it to the bottom of the tank the greater bulk of the suspended matter. By adopting a six-hour period of subsidence 75 per cent. of micro-organisms are removed. After subsidence the water passes to (*c*) the filter proper, which consists of a steel cylinder open above and closed below. Inside the true bottom of the cylinder there is a false bottom, on which is laid the filtering material, which consists of a layer of gravel covered with about 40 inches of sand. The upper part of the cylinder is double, enclosing a circular space into which the water passes; it flows over the lip of the interior cylinder, and thence through the filter bed to the exit pipe.

The action of the filter is both chemical and mechani-

cal. If the water contains carbonate of lime, the chemical reaction which takes place is as follows:

$$Al_2(SO_4)_3 + 3CaCO_3 = Al_2(CO_3)_3 + 3CaSO_4.$$
$$Al_2(CO_3)_3 + 6H_2O = 2Al(OH)_3 + 3H_2O + 3CO_2.$$

The hydrate of alumina formed entangles within its flaky, jelly-like substance minute material of all kinds. Most of this subsides by gravity in the subsidence tank, and any which remains in suspension is arrested in the upper layers of the filter bed, thus forming a scum not unlike the biological scum formed in ordinary sand filtration, and having a precisely similar action.

The Jewell filters in use in Egypt are reported to reduce the number of organisms per cubic centimetre from 700 to 4,700 in the raw water to from 9 to 27 in the filtered water.

In addition to the Jewell pattern, other varieties of rapid filters are on the market, notably Bell's, in which the beds in the filter chamber are composed of silver sand. In the Edinburgh installation each filter is able to deal with from 6,000 to 10,000 gallons per hour.

(*c*) *Anderson's revolving Purifier.*—The apparatus consists of a revolving cylinder containing a quantity of scrap iron. The water to be purified is passed through the cylinder, which, as it slowly revolves, brings it into constant and violent contact with the pieces of iron. In consequence the water takes up from $\frac{1}{10}$ to $\frac{1}{5}$ grain of iron oxide per gallon. By causing the effluent water to flow along shallow open troughs, this oxide is thrown out of solution, and the treated water is then allowed to deposit in sedimentation reservoirs. The effect of the process is to rid the water of about 63 per cent. of organic matter, and to reduce the number of micro-organisms from 7,000 per cubic centimetre to about 40 per cubic centimetre. This system gets rid of 95 to 97 per cent. of all organisms, and is slightly inferior to and more expensive than sand filtration.

(2) DOMESTIC FILTRATION.—Filtration on a small

scale for domestic purposes is now usually effected by two kinds of filters—the Pasteur-Chamberland and the Berkefeld.

The older varieties of filters, constructed of charcoal, asbestos, spongy iron, and polarite, have now practically disappeared in the tropics.

The disadvantage of the Pasteur filter is that a considerable amount of pressure is required before water can be obtained in any quantity. Ordinary river water in the tropics is usually very turbid, so that it rapidly clogs the filter candles, with the result that water ceases to pass. It is now fully recognized that no filters of this type can be of general utility in the tropics, unless they are worked in connection with a clarifying apparatus.

3. **Chemical**—(1) MECHANICAL.—Alum and lime are used as merely mechanical purifiers; they have no specific action on the water. They simply form a precipitate which falls to the bottom, carrying with it most of the microbes and organic impurities.

(2) GERMICIDAL.—The germicides used are—(*a*) the halogens; (*b*) permanganate of potassium; (*c*) acid sulphate of soda; (*d*) ozone; (*e*) the ultra-violet rays.

(*a*) *The Halogens.*—Bromine and iodine have been used with success to sterilize water, the former by Schumberg, the latter by Vaillard, but these methods have now been abandoned in favour of chlorine.

Chlorine.—This element was successfully used in all the theatres of the Great War, and practically replaced all other methods of water purification for military purposes. Many forms of the apparatus have been designed, but the simplest methods of treating a doubtful water is to add bleaching powder (chloride of lime) to it.*

Test for Ascertaining the Amount of Bleaching Powder required to Purify a Sample of Water.—To ascertain the amount of bleaching powder required one needs only

* *Ministry of Health* Circular 241, issued September, 1921.

(*a*) a weak solution of ordinary starch in water; (*b*) a solution of iodide of potassium—1 dram to the ounce; and (*c*) three or four small enamelled iron mugs. During the war this apparatus was packed in a small box and supplied to each unit which had a medical officer.

Method of Applying the Test.—Add 30 grains of bleaching powder, made into an emulsion with a wineglassful of water, to a tank holding 100 gallons. At the end of half an hour take a small mug or glassful of the water, and add 10 drops of the weak solution of starch and an equal quantity of the solution of iodide of potassium. If a blue colour forms and remains, sufficient bleaching powder has been added; if the blue colour fades, add another 30 grains of bleaching powder to the tank and test again.

Receptacles for water purified by bleaching powder should be scrubbed out every other day with a solution of bleaching powder, one teaspoonful to the gallon.

For isolated units without tanks of known capacity, two petrol or other tins of known capacity can be used in the following manner: Prepare an emulsion with a teaspoonful (60 grains) of bleaching powder and 2 gallons of water, and shake well. Six ounces of this prepared solution should then be added to each 2 gallons of the water to be treated. The water so treated should taste slightly of chlorine, and give a blue colour when treated with potassium iodide and starch solution.

If taste and the blue colour with the starch and iodide test are both absent, another 30 grains of bleaching powder should be added to the strong solution, and the test repeated with a fresh tin of water. In this manner the correct amount of bleaching powder will be ascertained, and any number of 2-gallon receptacles can then be quickly treated by adding 6 ounces of the strong solution to each.

The strong solution of a teaspoonful of bleaching powder to 2 gallons of water must be carefully labelled,

and be shaken well before use. It must be made fresh daily.

Method of Sterilizing Water for Small Bodies of Men.—The following method enables one to sterilize water a pint at a time, but requires the preparation of a special solution for the purpose:

Preparation of Special Solution.—Take ½ ounce (1 tablespoonful) of bleaching powder and macerate for one hour in 1 pint of water placed in a stoppered bottle. Then add 1 ounce (2 tablespoonfuls) of pure Epsom salts (crystallized sulphate of magnesia). Shake the mixture and allow it to deposit, and pour off the clear liquor, which contains approximately 0·5 per cent. "available chlorine." Discard the deposit.

If the bleaching powder is not fresh—*i.e.*, if it does not smell strongly of chlorine—use double or treble the quantity (2 or 3 tablespoonfuls).

The clear solution should be bottled at once, and the bottle should be kept wrapped in a double layer of brown paper to exclude the action of light as far as possible. It should have a well-fitting cork which has been dipped in a melted candle for five minutes.

The bottle should be labelled, "Hypochlorite Solution," with date of preparation.

If kept in a dark and cool place the solution will keep for a week, but it is better to make it twice weekly.

Method of Use.—Two drops of this clear liquid added to 1 pint of water is equivalent to the amount usually added to suspected water-supplies in France.

This method is specially applicable for chlorinating small quantities of drinking water, which, by this process, is purified without any appreciable alteration in taste or appearance.

Bleaching powder has been used for the treatment of public water-supplies by means of an apparatus which consists of a vertical cylinder capable of holding 7,000 gallons. The water enters at the top of the cylinder,

and leaves at the base. A mixture of the bleaching powder is pumped in measured quantities into the water, which by a system of baffle plates is retained in the cylinder for an hour. In the earlier experiments neutralization of the chlorine was effected by the addition of a small quantity of bisulphate of soda, which was introduced as the water was leaving the sterilized chamber. It was found, however, that when the chlorination was properly carried out—*i.e.*, when sufficient, but no excess, of chlorinated lime was added—this addition of bisulphate of soda was unnecessary.

The water as it leaves the cylinder flows into a galvanized iron tank and over a slotted weir, so graduated that the amount of water flowing at any given time may easily be measured.

In experiments conducted by the late Professor Sims Woodhead, in which 1 part of chlorine was added to from 1,000,000 to 4,000,000 parts of water, no *B. coli* or any of its congeners were found in from 150 to 500 c.c.

The amount of chlorine remaining at the end of the period of contact may be readily measured by the following simple test, which can be carried out by an intelligent layman: Add a crystal of iodide of potassium, a few drops of acetic acid, and a tablespoonful of starch solution to a litre of the treated water in a glass jug held over a sheet of white paper. If a blue tint appears, too much chlorine is being added. A violet tint is the proper "end reaction," showing the presence of a trace of chlorine. If the water remains uncoloured, the amount of chlorine present is probably insufficient to ensure sterilization.

The success of this method depends on the quality of the bleaching powder, which, according to B.P., should contain 33 per cent. free chlorine.

(*b*) *Potassium Permanganate.*—It has been claimed that $\frac{1}{2}$ grain to a gallon will sterilize a water in one hour. Such statements are misleading as, the process of

sterilization being one of oxidation, the quantity of chemical required depends largely on the quantity of oxidizable organic matter present.

Potassium permanganate has fallen largely into disuse, as the colour imparted is objectionable and the action feeble and uncertain.

Field Service Sanitary Notes, India, 1919, says: "It has, however, a great lethal action for cholera vibrios, for which reason, it is still used as a rough-and-ready method of sterilizing wells. To obtain the best effect, commence by adding 1 ounce of potassium permanganate for each 2,000 gallons, sprinkling the crystals over the water surface. Wait twenty to thirty minutes and then withdraw a bucketful, noting whether the pink colour remains. If not, add permanganate, ounce by ounce, until the colour is not discharged by the organic matter in the water. The well should be left untouched for twenty-four hours."

(*c*) *Acid Sulphate of Soda.*—This method depends on the liberation of free sulphuric acid from tablets containing 15 grains of acid sulphate of soda. One tablet dissolved in a pint of water destroys all organisms of the coli group after half an hour's action. The tablets readily deliquesce if not preserved in accurately stoppered bottles. The free acid is very destructive, and the process can only be carried out in glass, earthenware, or enamelled vessels.

This method has now been replaced by chlorination.

(*d*) *Ozone.*—The sterilization of water by ozone is largely used in France and Germany, but the method is expensive and not easily adapted to tropical requirements.

(*e*) *Ultra-Violet Rays.*—The method described in some detail in the previous edition of this book is still in use at Marseilles. Water previously clarified is passed through a quartz-tube mercury-vapour lamp three times. No *B. coli* found, and bacteria are said to be reduced 98·3 per cent.

Favourable reports by Thresh and Bealle lead

Rosenau to think the system will receive much attention in the future, but until the use of electricity becomes more general the method is unlikely to be largely used in the tropics.

Baths and Swimming Pools.

There is no doubt that baths and swimming pools can and do sometimes transmit disease—*e.g.*, bilharzia and intestinal infections; inflammatory infections of the upper respiratory tract and conjunctivæ; injury and inflammation of the ears; skin diseases, etc. Typhoid fever and diarrhœal conditions have been traced, on reasonably reliable evidence, to swimming pools.

Rosenau says one of the essentials in the sanitation of swimming pools is to require a shower-bath with a liberal use of soap before entering the tank, but, as can be readily realized, this is quite impracticable in the tropics, so that the danger of bathing *ghats* and pools is an ever-constant source of anxiety to the health officer.

Latrines and urinal accommodation is now always provided for in designing new swimming baths; such accommodation should therefore be established where none exists.

Ice.

Manufactured ice may contain more bacteria than the water from which it was made, as low temperatures alone do not destroy bacteria. On the contrary, they appear to favour bacterial longevity, doubtless by diminishing destructive metabolism. Frozen food materials—such as ice-cream, milk, and egg substance—favour the existence of bacteria at low temperatures not because they are foods, but apparently because they furnish physical conditions which probably protect bacteria.

Rosenau details a number of outbreaks of typhoid fever which have been traced to polluted ice. It has come within the author's experience that an ice-pudding associated with a case of cholera was found to contain a large number of cholera vibrios.

CHAPTER IV

FOOD AND FEEDING

THE foodstuffs used in various parts of the world are legion, but all the important constituents of them fall under one of the following six headings:

1. Nitrogenous compounds, or proteins.
2. Fats.
3. Carbohydrates, including sugars, starches, and various kinds of vegetable foods.
4. Salts.
5. Water.
6. Vitamins (accessory food factors).

In addition to these six essentials, there is an important group of articles, such as tea, coffee, and condiments, used by civilized man throughout the globe.

Each of these six groups has more or less specialized functions, which may be stated as follows:

1. **Proteins.**—The functions of nitrogenous foods are primarily—

> To build up the tissues and repair the wear and tear in the body.

Secondarily—

> To be used as heat-energy producers.
> To form fat.

2. **Fats.**—Fats are chiefly valuable as heat-energy producers.

3. **Carbohydrates.**—Carbohydrates act in a very similar way to fats, and to a certain extent they are *interchangeable* with them.

It is generally taught that in cold climates the fat

should be increased, and in warm climates the carbohydrates; but we dispute this statement, and consider that the amount of food of all varieties should be much the same in all latitudes.

4. **Salts.**—The salts necessary for the preservation of health are many. The salts of the vegetable acids—such as are found in fruits and vegetables—are essential for our tropical dietaries. When absent or deficient from food, a state of malnutrition results, which, if continued, develops into scurvy. Fruits and fresh vegetables, therefore, are very important articles of diet, though of small nutritive value.

Common salt is an imperative necessity for life and health, as it supplies the soda necessary for the salivary digestion and the chlorine for the hydrochloric acid of the gastric juice.

Next to it lime, phosphoric acid, potash, and soda are most important ingredients in the dietary. Iron is found in small quantity in almost every tissue of the body, and it is an essential constituent of the blood.

5. **Water.**—Water, to the extent of 2½ to 4 pints daily, is, as we have seen in the last chapter, an absolute necessity of life. Though not itself undergoing any chemical change, its presence is a necessary condition for the occurrence of chemical change in other bodies.

6. **Vitamins.**—Modern research on metabolism has shown that a diet of pure protein, fat, and carbohydrates, with due admixture of salts and water, is not sufficient to maintain health, though the quantities given may be theoretically correct, and that beri-beri and scurvy, rickets, sprue, and perhaps pellagra, are due to a deficiency of certain substances in the food, minute in amount, but essential to nutrition—hence these diseases have been styled "deficiency diseases." Such substances are necessary to the normal physiological processes of metabolism of the body. It appears that even in some *cases where* they are present, but where the

diet is limited and unvaried, and the individual is without appetite and proper assimilation, a deficiency disease may develop. It is improbable that these substances are in themselves nutritive; it seems more probable that they act as "activators," producing the synthesis of certain other nutrient bodies. Funk gave the name "vitamins" to such substances. Their chemical nature is imperfectly known. The small fraction of vitamins usually yielded by articles containing them is a serious difficulty in the way of elucidating their nature and composition.

Vitamins are not destroyed by freezing or refrigeration. The rate of destruction of vitamins depends more upon the length of time to which they are exposed to oxygen than upon the temperature. If exposed to oxygen, vitamins are slowly destroyed, even when kept at freezing-point. They are destroyed less rapidly at low temperatures than at high temperatures. The optimum conditions for preserving vitamins appear to be: (1) Absence of oxygen; (2) neutral or feebly acid reaction; (3) dry condition (rather than in solution); (4) low temperature.

There are vitamins necessary for the maintenance of nutrition, and others necessary for growth.

Confusion has arisen over failure to differentiate the fact that there are three accessory growth substances all grouped together as "vitamins."

1. *Fat-Soluble A.*—The antirachitic vitamin is necessary for normal growth and development to occur in young animals.

Certain experimental evidence would seem to indicate that deficiency of fat-soluble A vitamin in the diet is one of the causes of the defective nutrition which ultimately manifests itself as rickets, but opinion is not unanimous on this point.

The antirachitic vitamin (now considered as probably *identical with* fat-soluble A vitamin) cannot be extracted

from animal tissues by water, but is soluble in fat and in substances which dissolve fats.

2. *Water-Soluble B* is the antineuritic factor. It withstands desiccation and prevents the occurrence of beri-beri in man, and analogous diseases (polyneuritis) in animals. It is also necessary to ensure satisfactory growth and development in young animals. The antineuritic vitamin withstands drying for long periods of time, and this is consonant with the fact that its principal sources are dry foodstuffs.

3. *Water-Soluble C* is the antiscorbutic vitamin, possessing the power of preventing or curing disturbances in metabolism which result in the disease known as scurvy when this vitamin is lacking in the diet.

The antiscorbutic vitamin is soluble in water and in alcohol, and can be dialyzed and filtered through a porcelain filter without appreciable loss.

The vitamin doctrine has recently found critics in Orr and Elliot, the former working at the Rowlett Institute.

Hamill gives the following account of the distribution of the vitamins in nature :

1. The antirachitic (or fat-soluble A) vitamin is found in certain fats of animal origin, such, for instance, as beef fat, cod-liver oil, the fat of kidneys, heart muscle, and liver tissues, also butter, milk, and cream. The primary source of the vitamin is, however, the green leaves of plants, and it is from the consumption of these that plant-eating animals obtain the vitamin and store it in the fatty tissues of their bodies. The vitamin in cod-liver oil must similarly be presumed to have been ultimately derived from the tissues of algæ, or sea-water green plants.

Root vegetables in general are deficient in fat-soluble A vitamin (though certain of them, such as carrots, seem to contain appreciable amounts of this vitamin), and so also are most oils and fats derived from plant sources, such as *olive oil, cotton*-seed oil, etc.

It is obvious that the fat of plant-eating animals may show great variation in its content of fat-soluble A vitamin according to whether the animal's diet included green plants or not. Thus, in the winter-time, if green food is lacking, the milk of cows, and butter made from it, is deficient in fat-soluble A vitamin; similarly, lard obtained from pigs fed on a diet from which green food is absent will lack fat-soluble A vitamin.

2. The antineuritic (or water-soluble B) vitamin occurs in the seeds of plants; the chief of these for food purposes are the cereals and edible pulses, which consequently form one of the main sources of supply of the antineuritic vitamin.

In cereals the vitamin is not distributed uniformly throughout the grain; the bulk of it is limited to the embryo, or germ, a small proportion being found in the bran (the pericarp and aleurone layer). In wheat and rice the germ appears to contain from five to ten times more of the vitamin than the bran. The endosperm is deficient in antineuritic vitamin.

In pulses the antineuritic vitamin appears to be uniformly distributed throughout the seed, its reserve food-supply being contained within the embryo itself, and not separately stored in endosperm, as is the case in cereal grains. Eggs are rich in the antineuritic vitamin, which has been found to remain unimpaired in dried eggs; this indicates that the ordinary process adopted for drying eggs does not destroy the vitamin.

Yeast is also rich in antineuritic vitamin; commercial preparations made from yeast are largely used as a substitute for meat extract in the preparation of soup cubes, etc., and retain the vitamin activity of the yeast unimpaired.

Meat is relatively deficient in the antineuritic vitamin, but it seems that the offal—*i.e.*, internal organs, such as heart and liver—contain it in rather larger amounts than the "flesh" or skeletal muscle. Fish, milk, and cheese also seem to be relatively poor in this vitamin.

3. The antiscorbutic vitamin is found in the green leaves of plants, especially members of the natural order Cruciferæ—*e.g.*, cabbage. When it is difficult to obtain a supply of green vegetables, seeds, such as mustard and cress, which in themselves are devoid of antiscorbutic properties, may be germinated; the seedlings are rich in antiscorbutic vitamin. Roots vary greatly in antiscorbutic power, swedes being superior to carrots and beetroots. Potatoes (tubers) and onions contain the antiscorbutic vitamin in appreciable amount. The vitamin is also present in fresh fruits; oranges and lemons contain it in considerable quantity, and are superior to the lime fruit in antiscorbutic properties. Preserved lime-juice, dried fruit, and dried vegetables are practically destitute of any antiscorbutic power. Both meat and milk have a low antiscorbutic value.

Eggs are a very useful addition to a diet, the yolk especially being rich in fat-soluble A and water-soluble B vitamins.

What is already known in regard to vitamins indicates their cardinal importance in nutrition, but it may here be remarked that in some quarters there appears to be a tendency to invoke unduly the vitamin hypothesis, and to make deductions and draw conclusions which information at present available is insufficient to justify. Present knowledge in regard to vitamins necessitates caution in its application to far-reaching practical problems in dietetics if the error of building too vast a superstructure on an insufficient foundation is to be avoided.

Lipoids.—These bodies are another group of substances which have recently attracted much attention. Lecithin is the best known of the group. They are required to enable amino-acids, fats, and salts to enter the cells of the body, and so form colloidal substances, and it has been suggested that vitamins are unable to enter the cells except as lipoidal compounds.

All proteins contain amino-acids, but these are nc

combined in the same proportions, and it appears possible that a minimum thereof is necessary for the growth, if not for the maintenance in health, of the organism.

Condiments play a very important part in the food of both European and native in the tropics, as they are substances which give flavour to the often tasteless articles of food, such as rice, which bulk largely in tropical dietaries. In addition, they stimulate secretion and digestion, but they do not, of course, form tissues or evolve energy.

The nutritive constituents of food, in accordance with their functions in the body, may be classified as follows :

Tissue Formers.	*Heat Energy Producers.*
Protein.	Protein.
Mineral substances.	Carbohydrates.
Water.	Fats.

Dietaries.

There are four criteria of the value of a dietary : (1) Nutritive value ; (2) heat-producing power ; (3) digestibility ; (4) cheapness.

The respiration calorimeter is the only accurate method of determining the quantity of the various constituents in diet. By this apparatus the work done, the heat generated, and the waste products eliminated are expressed in terms of the calorie, which, in energy, is the equivalent of 1·54 foot-tons, or, in other words, represents that amount of mechanical energy which is required to raise 1 ton in weight 1·54 feet in height.

It is convenient and usual in questions of nutrition to measure energy in terms of heat production, since work is convertible into heat, and may be measured in these terms. The unit of quantity of heat is termed a calorie, and is the amount of heat required to raise the temperature of 1 gramme of water through 1° Centigrade (*actually from* 15° C. to 16° C.). In nutrition the amount

of energy required is so great that inconveniently large numbers would be required to express it in terms of calories; consequently, the kilocalorie or large calorie is used. This unit is 1,000 calories, and represents the amount of heat necessary to raise 1 kilogramme of water from 15° C. to 16° C. In dietetics the term "Calorie" is frequently used for shortness instead of the term "kilocalorie," and is spelt with a capital initial letter to indicate that it represents the larger of the two heat units.

When the respiration calorimeter is not available, the quantity of the total food consumed by the person or persons under observation should be carefully weighed and records made. Then samples of the various constituents of this diet should be analyzed, with the view of determining the quantity of protein, carbohydrate, and fat contained therein.

Standard diets expressed in grammes have been determined for an average strong, healthy man weighing some 11 stone (68 to 70 kilogrammes), and living under average conditions of work in the temperate zone. The following table gives some examples of these standards:

Observer.	*Protein.*	*Carbohydrate.*	*Fat.*	*Calories.*
Ranke	100	240	100	2,324
Voit	118	500	56	3,055
Rubner ..	127	509	52	3,092
Moleschott ..	130	550	40	3,160
Atwater ..	125	—	—	—

A good standard diet adapted to English habits, and suitable for a man doing a moderate amount of muscular work, is given in the table on p. 60.

The following are typical tropical dietaries:

(1) **For Asiatics doing Very Little Work**.—*Early Morning Meal.*—Six ounces boiled rice, with a little dal

and vegetables, or 4 ounces atta (flour) in the form of unleavened bread, with $\frac{1}{3}$ drachm salt; and a little ghee (clarified butter) and vegetables.

Meal at Midday.—Ten ounces rice; 3 ounces dal, fish, or meat; 4 ounces vegetables; $\frac{1}{4}$ ounce ghee or oil; $\frac{1}{4}$ ounce each salt and condiments.

Meal at Night.—Exactly same as midday meal.

A Simple Typical Diet.

Constituents.	*Amount per Day.*	*Energy Value in Calories.*
	Oz.	
Meat	7	581
Canned meat	2	93
Bread	12	760
Biscuit	3	314
Rice	2	206
Oatmeal	1	118
Bacon	3	465
Butter	1	219
Cheese	1	126
Vegetables—		
Potatoes	6	180
Cabbage	2	180
Jam	3	243
Sugar	2	232
Milk (unsweetened condensed)	1	49
Tea	$\frac{3}{8}$	—
Salt	$\frac{1}{4}$	—
Pepper	$\frac{1}{100}$	—
Mustard	$\frac{1}{100}$	—
Pickles	$\frac{1}{2}$	—
Total	—	3,586

(Hamill.)

(2) **For Asiatics doing Hard Work.**—Early morning meal as for (1).

Midday Meal.—Twelve ounces rice, 4 ounces vegetables, $\frac{1}{4}$ ounce each ghee or oil, salt, or condiments.

Meal at Night.—Same as midday meal.

(3) **For Natives of Northern India doing Light Work**—*Morning Meal.*—Four ounces wheat or maize flour, 3 ounces rice, $\frac{1}{4}$ ounce salt, with a little ghee and vegetables.

Midday Meal.—Three ounces wheat or maize flour, 3 ounces rice, 3 ounces dal (or, if meat or fish eater, 4 ounces instead of dal), 4 ounces vegetables, 1 ounce ghee or oil, $\frac{1}{4}$ ounce salt, and 1 ounce condiments.

Meal at Night.—Same as midday meal.

(4) **Native of Northern India doing Hard Work**—*Morning and Night Meals.*—As for (3).

Midday Meal.—Six ounces wheat flour, or 7 ounces maize flour, and $\frac{1}{2}$ ounce ghee [instead of 1 ounce as (3)]. The rest exactly the same.

The diets of tropical natives are, of course, often varied by the introduction of other kinds of food, such as eggs, milk, cheese, fowls, etc. In this respect the lower caste of Indians have an advantage, as their diet is less restricted. It is a matter of common knowledge that the more the diet can be varied the better, as variety in food gives a better appetite and renders digestion easier.

The daily scales in general use in the Bengal gaols consisted of—

Rice	16 to 20 ounces.
Different dals	6 ounces.
Wheat flour or Indian corn ..	10 or 12 ounces.

These gaol dietaries represent the amounts absolutely essential.

A better standard is the ration of the Indian sepoy given in the table on p. 62.

The following ration has been issued to Aden camel-drivers: $1\frac{1}{2}$ pounds biscuit or rice, 1 pound wet dates, 2 ounces ghee, 2 ounces sugar, $\frac{1}{3}$ ounce coffee, $\frac{1}{2}$ ounce salt, 2 ounces onions, or $\frac{3}{4}$ ounce dal.

More than these amounts are usually consumed. *Chittenden considers* that the current estimations of the *amount of proteid* and total fuel value necessary for

hard work are excessive, but the researches of McCay in India do not support his view.

The body seeks to maintain a reserve supply of nitrogenous food for its cells. A man having a small reserve supply may be considered to be on a low plane of nutrition, and one with a large reserve on a high plane of nutrition. Those on a high plane are better able to resist such infectious diseases as beri-beri, leprosy, tuberculosis, pneumonia, typhoid fever, typhus, relapsing

Detail.	*Bread.*	*Fresh Meat.*	*Bacon.*	*Potatoes.*	*Tea.*	*Sugar.*	*Salt.*	*Pepper.*
	Lb.	Lb.	Oz.	Lb.	Oz.	Oz.	Oz.	Oz.
British troops ..	1	1	3	1	1	$2\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{36}$
Indian troops and followers	—	$\frac{1}{4}$	—	$\frac{1}{8}$	$\frac{1}{8}$	—	$\frac{1}{2}$	—

Detail.	*Atta.*	*Dal.*	*Ghee.*	*Turmeric.*	*Ginger.*	*Garlic.*	*Gur.*	*Fuel.*
	Lb.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Lb.
British troops ..	—	—	—	—	—	—	—	3
Indian troops and followers	$1\frac{1}{2}$	4	2	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{6}$	1	$1\frac{1}{2}$

fever, and plague, than those on a low plane. White men in the tropics, when not liberally supplied with nitrogenous food, fall ready victims to infectious diseases. They have placed themselves, from a dietetic standpoint, on a level with the native, and, like them, soon succumb to an infection that their wiser or more fortunate brothers are able to successfully resist. Many of the natives of the tropics are in a state of chronic starvation ; hence the folly of intentionally placing white men in the same

condition is apparent. The immunity of Englishmen to the infectious diseases that decimate the aborigines of tropical countries is due—in part, at least—to their being better fed on nitrogenous food.

The natives of India are firm believers in a liberal dietary. One of their favourite proverbs is, "Khya seer buna sher," meaning, He who eats a seer (2 pounds) of flour becomes a lion in strength.

Wilson's conclusion with regard to protein in his Report upon Egyptian Prison Diets is worth quoting:

"A minimum amount of protein is required daily, over and above which a certain excess is desirable; this minimum is different for different proteins, and is measured by the biological value of protein. In determining, therefore, the requisite amount of protein, it is essential to take into consideration the biological value of the protein components of the diet, and fix the daily quantities on this basis rather than on the nitrogen content. In determining the amount of protein, the defective absorption of vegetable proteins must be allowed for."

Mixed and Vegetable Diets Contrasted.

Animal food possesses certain advantages over vegetable, of which the most certain are the ready supply of blood-pigment, the larger percentage of proteins, the greater digestibility of animal fats, and the smaller bulk required. A vegetable dietary, unless carefully selected, usually contains insufficient nitrogen and an excess of carbohydrates. It is bulky, less digestible in the stomach, and less completely absorbed. Vegetable albuminoids are less rapidly digested than those derived from animal sources, but a well-fed vegetable eater may display for a time as perfect health and energy as a meat eater. On the other hand, the argument from analogy with the herbivora, some of which are types of activity, is valueless, as man cannot digest cellulose or vegetable

fibre, whereas the horse or other animals can. The consistent vegetarian must either live on a diet deficient in protein or consume an excessive bulk of food. The adoption of the former course tends to diminish energy and tissue resistance, and the latter is likely to lead to derangement of the digestive organs (Whitelegge and Newman). Chittenden's dietary, if continued sufficiently long, lowers the resistance of the body against disease in the tropics; and this can scarcely be surprising, as he maintains that 0·12 gramme of nitrogen per diem per kilogramme of body weight is sufficient to keep a man in health. This is certainly not so in the tropics. And we doubt its general application to temperate and cold climates, where one would expect more food to be required.

Tropical Animal Food Products.

The various kinds of flesh present no special points for consideration in the tropics, except the deficiency in flavour already referred to.

They are popularly held not to possess the same nutritive qualities as in temperate climates, but this contention is not easy to establish experimentally.

The inferior quality of tropical foodstuffs is generally due to carelessness in production.

For instance, the smallness of the Indian egg is due to the want of care in breeding fowls and in feeding them. They are generally allowed to pick up any food they can get. There is no reason why large fowls and large eggs should not be obtainable in hot climates; and where residents have the energy to go in systematically for poultry-farming it always pays.

Milk.—Milk is a staple article of diet amongst many tropical natives, but is not consumed in some countries, such as Japan. The position in India is summarized by the following Government of India Resolution :

"The adulteration of milk is almost universal in Indian

bazaars, and a large proportion of the milk-supply is contaminated. In most cities the milk is in the hands of men ignorant of the elements of sanitation and addicted to uncleanly practices. Moreover, the milk is liable to be contaminated in transit. On the other hand, the price of milk is high, and the problem of improving the purity without raising the price is a difficult one."

The word "milk" in England, unless qualified, means cow's milk, but in hot climates it may mean cow's, buffalo's, goat's, or even sheep's milk. The two chief sources of milk are, however, the cow and the buffalo, and most samples in warm countries consist of a mixture of both.

The average of 350 samples analyzed by the author was as follows:

	Cow's.	Buffalo's.
Water	88·7	83·7
Total solids	11·3	16·3
Non-fatty solids ..	8·3	10·0
Fat	3·0	6·3
Ash	0·7	0·7

The following summary of a large number of analyses shows that the composition of buffalo's milk may be stated as under:

1. Specific gravity ..	10·27 to 10·35	
2. Total solids ..	13·82 ,, 22·90	per cent.
3. Fat	5·00 ,, 11·60	,,
4. Solids not fat ..	8·82 ,, 11·30	,,
5. Lactose	4·03 ,, 5·25	,,
6. Ash	0·75 ,, 0·80	,,
7. Water	77·1 ,, 86·18	,,

Milk, to be even reasonably safe, should not show more than half a million micro-organisms of the coli group present in the tenth of a cubic centimetre.

Centrifugalized Sediment.—Only a few streptococci should be present, and pus cells should be absent.

Chemical and bacteriological standards may be set

down as above, but no laboratory report can accurately indicate the essential " goodness " of a milk sample.

Milk is like no other food but raw eggs. It is the only other product of a living animal used by man. All other products are taken from the animal after it has been killed. Milk, therefore, being an animal secretion, varies with the breed, food, water-supply, and even the temper of the animal. Milk secreted in the enervating climate of the tropics must be entirely different from that secreted in England.

The amount of vitamins present depends entirely on the food of the cow. Attractive sterile milk powders* have recently been put on the market which appear specially adapted for tropical use. Apart from employment as a substitute for fresh milk in the hand-rearing of infants, there is a wide field of usefulness for milk powder as a food for healthy adults and invalids.

On the Mediterranean littoral and very many places in and near the tropics, where cow's milk is unobtainable and goat's milk dangerous, dried milk has a very large range of application. There has been considerable divergence of opinion in regard to dried milk, but recent research seems to show that in the ordinary processes of drying milk its antiscorbutic properties are not seriously impaired.

Produced and dried under the almost ideal conditions attained by some manufacturers from milk fed on English or colonial pastures, milk powder is rich in vitamins, and presents a solution of the manifold difficulties indicated above in preserving pure milk in the tropics.

Milk should be boiled or pasteurized before use, as many diseases—such as tuberculosis and enteric fever—are spread by contaminated milk. Boiled milk is said to be more digestible than fresh milk ; it is, however, less palatable to most people, and no doubt loses some of its nutritive value and some important salts in boiling.

* *E.g.*, Glaxo.

But whatever disadvantages boiled milk may have, they are outweighed by the protection secured against so frequent a source of infection by specific disease poisons.

Cream is a most valuable and nutritious food, easy of digestion in moderate quantity.

Skim milk and whey are not very nourishing, but are easy of assimilation, and are agreeable articles of food for invalids.

Cheese.—Cheese does not receive the amount of consideration it deserves in tropical dietaries. It is a more concentrated food than meat, but less palatable.

That cheese is not readily digested by some persons is well known. The fat, which constitutes one-third of its composition, forms a waterproof coating which prevents the access of the digestive juices to the casein. Hence the importance of reducing it to a state of fine division before it is swallowed. This may be done by carefully chewing with some farinaceous substance, such as bread or biscuit. The process of mastication may be assisted by grating the cheese.

The best solvent of cheese is bicarbonate of potash, because casein forms soluble compounds with the alkalies. About 5 grains of bicarbonate of potassium is sufficient for 4 ounces of cheese, either grated or chopped into small fragments. By the addition of milk and eggs a very savoury and exceedingly nutritious pudding can be prepared, which is a grateful change to tropical dietaries.

The proper place for cheese in a well-arranged diet is as a substitute for, and not as an appendage to, meat. There is, however, one exception to this rule, and that is the correctness of taking a small piece of cheese at the end of a meat meal for, paradoxical as it may seem, digestive reasons.

According to the old adage, cheese is a "crusty elf, digesting all things but itself," and in this there is the element of *truth*. Cheese contains elements of the

character of ferments, which tend to set up a fermentation process in the food when it passes into the stomach, and thus to promote digestion. But if the cheese be taken in excess at such a time, the digestive action is paralyzed, and indigestion is the natural consequence, thus justifying the wisdom of our forefathers.

The cheaper cheeses are often more nourishing and more digestible than the expensive ones.

Butter.—Good butter should be of a rich yellow colour, which deepens with the richness of the pasture. Cows fed on the dry grass of the tropics give an inferior product, whilst buffalo cream always yields a dead white butter. Various substances, such as annatto and an Indian nut called *lutka*, are added to increase or produce the popular colour. Butter from moderately ripe cream has a fine flavour, and, well made, ought to remain good and sweet for a week. Butter prepared from pasteurized cream is lacking in flavour.

Ghee, or clarified butter, takes the place of butter in the diet of Indians. It is a wholesome and nutritious fat, but its flavour is repulsive to Europeans.

Tropical Vegetable Food Products.

The vast bulk of the food of the majority of tropical residents consists of these products, and they may be considered in some detail. There is very little information available as to the chemical composition, the biological value, or the absorptions of tropical food materials except the work of McCay in India and Wilson in Cairo.

The Vegetable Foods may be divided into five groups:

GROUP I.: CEREALS.—These comprise the edible grains, such as wheat, oats, Indian corn, rice, etc. Of these wheat is preferred as a food, for the following reasons:

(1) The grain is easily separated from the chaff, which does not adhere to it, as in the case of barley, oats, rice, etc.

(2) The yield of flour is very large.

(3) Owing to the peculiar constitution of wheat, light and spongy bread is readily made from it.

In many tropical places wheat is ground between small hand-moved stones. The bran is removed by sifting, and the flour contains the germ and the endosperm. It is often adulterated with barley, maize, and linseed. McCay found that the absorption of wheat in India was very complete, amounting to about 80·5 per cent. of the total protein elements.

Modern steam roller-milling removes both bran and germ, and the flour is composed solely of the endosperm, of which the central portion, poor in protein and rich in starch, form the "patents," the remaining part "household" or "baker's flour." "Standard flour" from the whole wheat contains the entire grain.

(4) The proportion of the chemical constituents present renders wheat well fitted for the general sustenance of man (Church).

Bread.—Bread can be manufactured in a variety of ways, but all the methods aim at the aeration of a mixture of flour and water, and subsequent cooking at a temperature of about 450° F.

A good sample of bread should be well baked (not burnt), light, and spongy, the crumb being well permeated with little cavities. It should be thoroughly kneaded, of good colour (brown or white), not acid to the taste, not bitter, not too moist. When set aside, the lower part should not become sodden. A 4-pound loaf loses about ¼ ounce in twenty-four hours and about 7 ounces in sixty hours. This loss will vary with the temperature, draughts of air, etc.

Bread may have the following defects:

(1) It may be sodden or heavy, owing to bad flour or yeast, or owing to imperfect baking.

(2) It may be sour, owing to bad flour, or to fermentation having been allowed to proceed too far. A

slight degree of sourness in leavened bread is not objected to.

(3) It may be bitter, owing to bitter yeast.

(4) Finally, it may be mouldy, due to the bread having been too moist originally, having been stored in a damp place, or kept too long, or to bad flour having been used.

Biscuit.—Biscuit should be well baked, but not burnt. It should float and partially dissolve in water. When struck it should give a ringing sound, and a piece put in the mouth should thoroughly soften down. Being almost free from water, biscuit contains a large amount of nutritive material in an easily digestible form, and keeps for a considerable time. Three pounds of biscuits are equal in nourishment to five pounds of bread.

Oatmeal.—Oatmeal is the most nutritious of all cereals and very rich in fat. Oats prepared by rolling instead of grinding, and heated during the rolling process, are more digestible and easily cooked than ordinary oatmeal, and constitute the much-advertised preparations of oats, now so deservedly popular in Europe and America, but comparatively little used in the tropics.

Maize.—Maize, or Indian corn, is ground into meal in the tropics in a similar way to wheat, but it is often eaten roasted in the cob, either with or without butter or ghee. The cereal is extremely nutritious, but has some disadvantages. Owing to the large amount of fat, it develops a disagreeable rancid flavour on keeping, and, from its deficiency in gluten, it is not adapted for making bread, unless mixed with wheat flour. It has been wrongfully accused of causing pellagra.

It is, all things considered, one of the best of our tropical foods.

Cornflour is prepared from maize by washing away the protein and fat by means of dilute alkaline solution, so that little but starch is left.

Rice.—Rice is believed to be the staple diet of some *four hundred* millions of Indians, Chinese, Japanese,

and Malays. It is the poorest of all cereals in protein, fat, and mineral matter, and for this reason has to be consumed in large quantities to provide a bare sufficiency of this important factor, as it has fully 76 per cent. of starch. The starch has the advantage of being present in small and easily digested grains. When boiled, rice swells up and absorbs nearly five times its weight of water, while some of its mineral constituents are lost by solution. It is preferable, therefore, to cook it by steaming.

Rice is only moderately easy of digestion in the stomach; 2½ ounces cooked by boiling require three and a half hours for disposal, so that rice not only distends the stomach owing to its bulk, but keeps it distended during digestion.

In the intestines nearly all the starch is absorbed, but only 45 to 85 per cent. of the protein. This lack of absorption of protein is a serious dietetic defect. The percentage of nitrogen absorbed varies with the quantity of the rice—from 45·76 per cent. in a mixed diet containing 32 ounces of rice to 68·33 per cent. in a similar diet containing only 20 ounces of the cereal. Mixed diets containing large quantities of rice tend to a low standard of protein absorption.

There are two kinds of rice—viz.:

(1) The Indian, or "unpolished" rice or "paddy," which is prepared by—(*a*) soakage in water for twenty-four to forty-eight hours, (*b*) steaming in cylinders, and (*c*) drying in the sun. This variety is yellowish-brown in colour, has lost little of its protein, and carries, attached to it, the outer layers of the grain.

(2) The Burma, Rangoon, white, or "polished" rice, which is prepared by milling the unhusked grain until the husk, the pericarp, and the surface layers of the seed are removed, producing a clean white product denuded of its outer layers and portion of its protein.

Many authorities believe that this method, by sepa-

rating the subpericarpal layers from the rice, deprives it of water-soluble B vitamin, and is the cause of beri-beri. Rice is not adapted to be an exclusive diet, but should be eaten along with other substances rich in protein elements, such as eggs, cheese, or milk. Even as regards carbohydrates, it would require about 1 pound 3 ounces of rice to furnish the daily needs of an active man. This would entail the consumption of about 5 pounds of cooked rice daily.

GROUP II. : THE PULSES.—Lentils, such as the various kinds of "dal," are similar in composition to, but richer in phosphates than, peas and beans, and contain less sulphur.

The group is rich in protein—chiefly legumen, a substance allied to the casein of cheese. They are also rich in carbohydrates. Salts are fairly abundant, but phosphates are less so than in cereals. Like wheat, the seeds are weak in fat, and therefore require mixture with fats and carbohydrates to form a complete diet. Gram and ghee with potatoes is an example of a complete diet.

A mistake is very often made, chiefly by Europeans, in taking leguminous seeds as a vegetable with meat. Dal and similar pulses should be used as a substitute for meat, and are best combined with rice, which we have already seen to be deficient in proteins.

GROUP III. : THE ROOTS AND TUBERS.—These consist chiefly of carbohydrates, mostly in the form of starch, and very little other food material.

Potatoes.—This tuber consists of starch, sugar, and a trace of protein. When well cooked it is easily digestible. The juice of the potato is rich in water-soluble C vitamin.

Beetroot.—Beetroot, when young, is of some value as a food, on account of the sugar it contains.

Carrots and parsnips are of rather less value than beetroot.

GROUP IV.: GREEN VEGETABLES.—These consist of large quantities of water, much cellulose, and small quantities of sugar, gums, and allied bodies. The members of this group are chiefly valuable as sources of the water-soluble C vitamins, as flavouring agents, and as natural stimulants to the action of the bowels.

Onions.—These vegetables are valuable as condiments. They contain a larger amount of phosphates than any other succulent vegetable, excepting asparagus, and have a slight laxative action on the bowels. They are also said to be very valuable for persons with a rheumatic tendency.

The succulent fruits and salads are rich in the water-soluble C vitamins.

Cholera, enteric fever, and other diseases, may readily be conveyed by uncooked vegetables. For this reason, only vegetables grown under personal supervision and carefully washed before use should be eaten as salads. Both on account of their indigestibility, therefore, and the danger of contracting cholera or enteric fever, we are strongly of opinion that in tropical countries salads, as a rule, should be avoided.

Watercress is often grown in sewage water, and may spread enteric fever and worms. Even when obtained from the best sources, it should be well soaked in strong salt water, and then well washed in boiled water, before use.

GROUP V.: ALBUMINOUS NUTS.—The edible nuts, such as the walnut, are generally very rich in protein matter and fats, and contain some carbohydrates. The difficulties in their digestion are often great, but are diminished by grinding the nut into a fine powder.

They are popular with tropical natives.

In regard to mineral requirements, certain important groups of foodstuffs, such as most of the cereals and tubers, are low in calcium, whereas milk is rich in this important element. Milk, therefore, is able to correct

the calcium deficiency of these groups of foodstuffs, which must of necessity enter largely into most diets.

Beverages.

The beverages of civilized man the world over are—

1. Alcoholic liquors.
2. Tea and coffee.
3. Aerated waters.

1. **Alcohol.**—In childhood alcohol as a beverage is most injurious; in adult life a strictly moderate amount, with ordinary diet, may be taken or not, but it is not a necessity; in old age with failing strength and weight alcohol is most useful; in old age with increasing weight and obesity alcohol is most injurious—it increases the tendency to fatty heart, kidney troubles, and to apoplexy, with paralysis or sudden death.

Cantlie says: "The natives of warm climates, both by their religion and habits, shun alcohol. It is in no sense a food, and Europeans in tropical countries would do well to avoid its use altogether." Cantlie's statement is not in accordance with Indian experience, as the Hindus all over India, from the Sikh of the Punjab to the Madrassi butler of Trichinopoly, will drink all the alcohol they can get hold of, preferably in the form of whisky, rum, or brandy, imported or locally manufactured, or indigenous stimulants such as arrack and toddy.

Indian reformers are actually endeavouring to introduce some form of prohibition, whilst the Government is limiting the sale of all alcoholic beverages.

The action of alcohol may be considered—

(1) While it is still in the stomach.
(2) After it is absorbed from the stomach.

Alcohol in moderate doses, when taken with meals, has practically no action upon digestion or the absorption of food; but when taken apart from food, and especially

when not markedly diluted, it produces a dilation of the bloodvessels of the stomach, and may set up a chronic congestion.

It is absorbed without undergoing any change. The absorption is at first very rapid, but later becomes slower, apparently as a result of the alcohol exercising a poisoning action on the lining membrane of the stomach.

When absorbed it is rapidly oxidized, and liberates energy in the same way as sugars and fats. Its energy value is intermediate between those of sugar and fats, being 7 calories per gramme.

While these two true foods are oxidized to an almost unlimited extent, and when not immediately oxidized are largely stored in the body, alcohol can be dealt with only to a limited extent, and even in moderate doses it may be detected in the blood many hours after it has been administered. It cannot be stored for future use. Most people can fully oxidize about 2 ounces in the twenty-four hours, but the power of doing so varies in different people and in the same person at different times. Hence its value as a source of energy is limited.

Alcohol, acting as a drug, stimulates and quickens the heart. It dilates the bloodvessels, especially those of the skin, and thus, in spite of the increased action of the heart, the pressure of blood in the arteries is not raised. By dilating the vessels of the skin it allows more of the warm blood from the central parts of the body to come to the surface, and so produces a sensation of warmth. But the blood is thus rapidly cooled, and the temperature of the body falls; hence in exposure to cold alcohol is prejudicial.

On the nervous system it acts as a poison in the same way as do ether and chloroform, and, like these drugs, it first affects the higher centres of the brain; hence the critical faculties and the power of judgment are interfered with, and the individual, misjudging his own

cerebral activity, may feel convinced that it is working better than usual. But the application of such tests as doing rapid calculations show that this is a fallacy, and that the power of mental work is decreased. Later, the perception of sensation is blunted, and in this way the sense of fatigue may be removed. The poisoning gradually extends to the lower centres, and the motor powers of speech and locomotion are finally involved.

It is this action of alcohol on the nervous system which so markedly limits its uses as a food. A man may liberate the energy from the alcohol he takes, but long before any manifest symptoms are produced his power of judgment and his power of directing the finer actions of his muscles are so interfered with that he is unable to make full use of not only the energy liberated from the alcohol, but also of that liberated from the carbohydrates, fats, and proteins of his food. His working efficiency is thus decreased.

Alcohol may and does increase the pleasure of life by paralyzing the critical faculty, and it not only brings comfort to the weary by removing the power of appreciating the sense of fatigue, but by acting as a cardiac stimulant. In fever it is sometimes useful in increasing the loss of heat, and thus lowering the temperature.

In an address on alcohol in relation to industrial hygiene and efficiency which Sir Thomas Oliver gave before the Royal Society of Arts on March 29, 1922, he said: "So far as the man who uses alcohol sparingly and in moderation is concerned, neither experience nor physiology show that he is as a workman inferior to the abstainer. An experiment on a gigantic scale is being carried out by the United States, and the civilized world awaits with patience its results; for by many persons it is held that those nations have been the most progressive whose people have been protein consumers, largely of meat, and who have not denied themselves the luxury of alcohol. It cannot be said of the

Mohammedan races of Asia and of Eastern Europe, for example, that total abstinence has raised them to a higher plane of civilization or has conferred upon them those practical qualities so characteristic of the men of the West."

2. **Tea, Coffee, and Cocoa**—(1) *Tea.*—As a stomachic tonic, and as a safe way of introducing fluid into the system, tea is beneficent and hygienic. It was evidently introduced by the Chinese, owing to the calamities arising from drinking unboiled water. But boiled water being insipid, and the object of its being boiled not being evident to an ignorant and thoughtless people, the water was flavoured by the leaves of the tea-plant, a custom which has become universal.

The Chinese and Russians drink tea after their principal meal, and as a "drink" at any time. They do not drink tea during their meal, but after the meal is finished. Drinking tea during a meal is a British habit and the cause of many dyspeptic troubles. The best China tea, prepared by pouring boiling water over the leaves and immediately pouring off the water, is a wholesome fluid calculated to aid digestion, especially when taken after the meal is finished. When the tea is "drawn" for a long time, the tannic acid of the decoction, uniting with the albumin of the animal tissues, produces a leathery compound very difficult of digestion. Tea used in the Chinese fashion is a hygienic drink, but the British "afternoon tea" is an unnecessary and useless meal, especially when tea-drinking is merely an excuse for eating large amounts of hot buttered buns, scones, rich cakes, and such-like indigestible articles.

(2) *Coffee.*—Two or three mouthfuls of good coffee after a meal are an aid to digestion. One or two breakfastcupfuls diluted with half milk, and taken with some well-baked bread, constitutes the delightful Continental *petit déjeuner;* but similar quantities taken with a meal of eggs, fish, fowl, or flesh, are an impediment to

digestion. Taken at night, coffee frequently causes insomnia.

(3) *Cocoa.*—Cocoa contains a similar alkaloid to tea and coffee, but it is present in smaller quantity. In the way cocoa is generally taken the whole of the seed is eaten, so that, in addition to a stimulant, some food matter, principally of a carbohydrate kind, is present. It is, however, inconsiderable in amount, as the total weight of cocoa eaten is so small.

Condemnation cannot be too strong in regard to the habitual use of the drugs coco and kola in medicated wines. The action of the stimulating alkaloids which they contain is insidious, and a craving is often set up, leading to cocaine mania.

3. **Aerated Waters.**—These consist of water, or solutions of salts, with or without sugar and flavouring agents, aerated with carbonic acid gas. Carbonic acid gives a brightness and pleasant flavour to the water. Provided that no metallic poisons are added from lead, etc., in the machine used in preparing the water, simple aerated waters are not injurious; but it should be understood that, while carbonic acid gas under pressure has some germicidal properties, it does not render a polluted water safe from drinking.

The germicidal action of carbonic acid is most marked with reference to the cholera vibrio. It acts slowly, so that aerated water should be kept for at least a week or ten days in order to obtain it.

Cooking.

The objects of cooking food are twofold:

1. Æsthetic, to improve its appearance and to develop in it new flavours.
2. Hygienic, to sterilize it to some extent and to enable it to keep.

It is an error to suppose that cooking increases the *digestibility of food.* This is only true with regard to

vegetable foods. The digestibility of meat is diminished by cooking, although the increased attractiveness of cooked meat may render it indirectly more capable of digestion by calling forth a more profuse flow of digestive juices.

Ordinary cooking or pickling affords little protection if meat is infected with the germs of disease.

Disease caused by Food.

The essential constituents of diet may be deficient or in excess.

Overfeeding.—An excess of food, due to large or frequent meals, may accumulate in the intestines, causing fermentation and dyspepsia, with constipation or ineffective diarrhœa. Gout, obesity, gall-stones, and other conditions may arise from excess of food. Absorption of the products of putrefaction may give rise to a septic condition marked with fever, furred tongue, fœtid breath, heaviness, and possibly jaundice. Diseases of the blood may also arise from retention of waste products in the intestines.

Underfeeding.—Protracted insufficiency of diet is followed by wasting of the tissues. Adipose tissue is naturally the first to suffer, and may be almost completely absorbed, the other tissues following mainly in the inverse order of their importance to life. Physical and mental weakness ensue, followed by a debilitated condition that powerfully predisposes to certain diseases, notably relapsing fever, phthisis, and pneumonia, and perhaps all infectious diseases. Diarrhœa is apt to occur, adding still further to the general emaciation and prostration.

Ophthalmia, ulcers, and skin diseases of various kinds are common, and any disease that may have obtained a hold upon the system is aggravated by the impairment of nutrition. Death ensues when the loss reaches about 40 *per cent.* of the normal weight of the body.

Health may become affected by articles of food in the following ways:

1. Poisons may be derived from vessels in which the food has been stored, as in the case of tinned provisions. Poisonous substances—such as tyro-toxicon—may be developed either as a result of fermentation or from unknown causes.

2. Injurious substances may be added by way of adulteration, by improper manufacture, or by drugging of animals before death.

3. Certain kinds of shell-fish are liable to be occasionally poisonous, even in the fresh state, and disease may be conveyed by oysters, watercress, etc., grown under unhygienic conditions.

4. Putrefactive changes may have commenced in the food, and produce grave intestinal disturbance.

5. The flesh or milk of an animal suffering from certain specific or parasitic diseases—such as tuberculosis, trichinosis, hydatids—may impart the disease.

6. Vegetables may convey actinomycosis.

7. Food, especially milk, may become infected by the virus of diphtheria, enteric fever, cholera, or scarlet fever, from close contact with persons suffering from these diseases.

Disease in the individual, or more rarely idiosyncrasy apart from disease, may render certain kinds of food—such as shell-fish—injurious which to ordinary persons are wholesome (Osler).

CHAPTER V

CLOTHING IN THE TROPICS

In hot climates the surface of the body is best protected by materials which will readily reflect the sun's rays. But clothing has to be regulated according to its power of absorbing moisture, and to its non-interference with the healthy action of the skin and the free movements of all parts of the body. Moreover, its subsidiary uses, such as the protection of certain parts from pressure—as in the wearing of boots and shoes—and its adaptability to keep out wet, are points which require consideration.

The materials worn in the tropics are wool, silk, cotton, linen, and leather.

Wool.—Wool forms the natural covering of animals in cold and temperate climates. It owes its value to the fact that it contains an oil or fat, and that the wool, when woven into cloth, has numerous interstices, which imprison air and prevent heat passing through it. Hence flannel is not only warm, but cool. It should always be worn during the cold and rainy season in the tropics, and in "hill stations." During the hot season its desirability is doubtful.

The natural oil of the wool is one of the most important constituents of flannel, but, unfortunately, bad washing frequently removes this natural grease, and leaves the material practically worthless. Woollen goods should therefore be washed in water which is only just warm, and soap, which should be of a good quality, used sparingly. A little kerosene oil added to the water will *remove* gross dirt.

It is not necessary that underclothing should be of pure wool. For hot climates it is difficult to obtain it either thin or soft enough for comfort, but various mixtures of wool and cotton and loosely woven cotton materials, possessing all the advantages for tropical wear of pure wool, are on the market.

In the choice of woollen underclothing the touch is a great guide. There should be smoothness and great softness of texture; to the eye the texture should be close, the hairs standing out from the surface of equal length, and not long and straggling. The heavier the substance is in a given bulk the better. In the case of blankets, the closeness of the pile and the weight of the blanket are the best guides.

In woollen cloths the rules are the same. When held against the light, the cloth should be of uniform texture, without holes; when folded and suddenly stretched, it should give a clear ringing note. It should be very resistant when forcibly stretched, as the "tearing power" is the best way of judging if "shoddy" has been mixed with fresh wool.

Silk.—Silk, next to wool, is the best material for tropical underwear. The soft, soothing feeling of a silken vest is due to the fact that silk fibres are beautifully smooth, whereas wool, which is merely a variety of hair, presents a rough surface.

Cotton.—Cotton has the great practical advantages of being hard, durable, and cheap. It is introduced into most woollen materials to increase their durability and to prevent shrinking; for instance, it constitutes nearly a quarter of the excellent flannel from which the familiar grey shirt of the soldier is made.

In the form of various types of cellular clothing it is capital material for hot-weather wear.

Specially woven and dressed, it is very largely used as "*flannelette.*" This material, on account of its *inflammability, is dangerous* for wearing apparel.

Linen.—Linen possesses no advantage over cotton as an article of clothing. It can be woven into finer materials, and takes a high finish, so that it must be judged from an æsthetic rather than a hygienic point of view.

Indiarubber, Oilskin, and Waterproof.—Special waterproof fabrics have a very wide use during the rainy season. The following is a useful recipe for waterproofing ordinary materials :

Take 5 ounces of lanoline or wool fat and dissolve it in a gallon of petrol. The clothing is then immersed in the solution, the garment rung out, and the excess of solvent allowed to evaporate rapidly in the air.

Clothing impregnated with wool fat in this way may be worn both in rain or sun without ill effects. It permits the rapid evaporation of perspiration, and affords a better protection against rain than do fabrics waterproofed with alum preparations or other chemicals. Such garments are even more permeable to air than ordinary clothing, and also absorb less watery vapour. Moderate washing has no effect on the waterproofing, so that the effects of the procedure are fairly permanent. The expense is inconsiderable, the cost of waterproofing a suit of clothes being less than half a crown.

Boots.—Boots should be carefully fitted at all times, but require special consideration in the tropics.

They should be invariably "tried on" over a thick pair of socks, and may well be a size bigger than is actually necessary, to allow for the swelling of the extremities which is associated with hot weather, and for expansion of the foot in active exercise. They must not be tight over the instep, and great pains should be taken to see that there is plenty of room for the toes, especially the little one. The soles should be pliable, nothing being so tiring as a tropical walk in shoes with stiff soles. New boots should be frequently used for *short distances before* being worn for any length of time.

Castor oil is one of the best materials to rub into boots used for sporting purposes to render them soft and pliant. In Europe it is not very largely used for this purpose on the score of expense, but in the tropics it can often be obtained extremely cheaply.

Boots should always be worn in preference to shoes, in order to protect the ankles from the bites of mosquitoes.

Leggings and Puttees.—Experience has shown that a well-fitting legging is the best covering for riding, whilst the puttee forms an excellent protection for the lower extremities for walking. Like boots and socks, these articles require careful attention, as a tight-fitting legging or a carelessly applied puttee spells misery to the individual wearing it.

Drawers.—Everyone should wear drawers in the tropics. They promote cleanliness, and protect the internal organs from chills.

Cholera Belt.—The flannel belt much extolled by the older writers generally fails to answer the purpose for which it is intended. It is very difficult to keep in position, and either rucks up under the ribs or lies in a roll above the hips. In either case it is of little value as a protection, and after exercise it becomes converted into a wet poultice over the abdomen.

The use of the cholera belt should be restricted to night wear, when it is most useful. If a blanket is relied on in hot weather, it is frequently tossed off by the restless sleeper, with the result that the abdomen is chilled by the "draught" of the punkah or fan.

In the tropics this is undoubtedly a source of danger, and it should be carefully explained to recent arrivals in hot countries that, whereas chill in temperate climates usually leads to nothing more serious than coryza, in hot countries it is very likely to be followed by intestinal *troubles.*

The colour of articles should be carefully considered

when deciding the question of general suitability. It is well known that different colours possess in varying degrees the power of absorbing heat. Black has the highest capacity for absorption, white has the least, the order in which different colours absorb heat being as follows : Black, dark blue, light blue, dark green, turkey red, light green, dark yellow, pale straw, and white.

An experiment was made in the Philippines amongst the military forces of the United States Army with reference to the value of orange-red underclothing as a protective against heat, and especially as a preventative against heat exhaustion. This experiment was made following the report of the British officers in India that such clothing was much more comfortable than khaki or white in hot weather. The test clothing was distributed to half the men in each company, the other half wearing white garments of like texture as a control. In all 500 men wore the orange-red underwear under similar conditions of physique, food, and service, and careful records were kept of comparative amounts and nature of sickness amongst them, their feelings as to comfort or discomfort in the sun, their mental and bodily vigour, etc. The experiments continued for a year, and a record of the weights and blood examinations were kept throughout this period. It was found that the record of sick admissions was about the same for both groups ; they suffered equally from the heat of the sun, but those of the orange-red group suffered more from excessive perspiration, there was a greater loss of weight in the hot season by nearly a pound per man, and the blood changes noted in tropical climates—decrease of red cells and loss of hæmoglobin—were more pronounced. The blood-pressure also showed a greater loss, and the temperature, pulse, and respiration showed a slightly higher rate for this group. The admissions for heat exhaustion and febricula were not reduced by the *orange-red clothing*, and the symptoms due to heat

were about the same in the two groups. Only 16 men out of 500 preferred the coloured underclothing, and the persistent complaints of greater heat, greater weight, and excessive perspiration indicated that the coloured garments were more receptive to the heat rays than the white. The conclusion of the board conducting the experiment was that the orange-red clothing added materially to the burden of heat on the system, and that no beneficial effects were observed from its use.

The Clothing of Children.—An infant requires to be especially protected by clothing, because it loses heat quickly by evaporation, its surface being large in proportion to its bulk.

Babies should wear wool next to the skin all the year round in the tropics, only varying the thickness to suit the season. It shows a poverty of resource to expose the upper and lower parts of the bodies of children in order to give them greater freedom of movement. This can be accomplished without depriving them of clothing. Deprivation of clothing has distinctly injurious effects upon children, who require a large amount of heat to enable them to carry on the process of growth and development. The habit, therefore, of tying up a baby's sleeves with ribbons and allowing older children to run about with legs bare cannot be too strongly condemned, as a large part of the body is thereby exposed to sudden chilling. A child has only a certain amount of nerve force available for the vital functions of breathing, digestion, etc.; and if an undue amount of this is expended in the maintenance of bodily heat the other functions suffer, with the result that digestion is enfeebled and constipation or diarrhœa ensues.

Even in the tropics, therefore, a child's clothing should be soft, light, warm, and loose, and so arranged that it can easily be taken off. Every garment should be made to fasten with tapes and buttons, and an *infant's binder* should invariably be sewn on, and not *astened with* a safety-pin.

Long clothes are universally condemned by all authorities.

All children should wear a vest of natural wool in the cool season, and silk in the hot weather. Older children should wear combinations, as these garments avoid undue pressure round the waist.

Children's bedclothes should be light and warm, and the coloured insanitary blankets, which are so popular in the tropics, should be replaced by white blankets, which do "show the dirt."

Mackintoshes should be placed over the children's mattresses, but they must never be put on over a baby's napkin, as the rubber causes irritation of the skin. Eiderdown quilts are undesirable for children's beds, as they are not porous and cannot be washed.

Children's boots should be made by a good bootmaker, and the only point to be insisted on is that the inner edge of the sole should be in a perfectly straight line, and not inclined towards the outside from the ball of the toe forwards.

Children's boots should invariably be made to lace up, and not to button. This method of fastening allows of making one part tight and another loose, as circumstances require. They should only be laced as far as the last hole but one, and tied loosely. If laced right up to the top, the boot-lace often slips on to the leg, and chafes and constricts it.

Sandals have been strongly advocated for children, but they are not recommended for use in the tropics, as they do not protect the feet from the bites of mosquitoes.

Babies' heads should not be wrapped up, especially in the tropics. For older children light, loose-fitting topees and hats should be used, and headgear of the type of Dutch bonnets avoided. A light, broad-brimmed, mushroom-shaped sun-hat is all that is necessary for wearing in the sun, whilst a similar covering in light

straw is easily devised for use after sundown. The sun-hat must be worn out of doors even in the early morning, as the sun is just as likely to produce sunstroke in the morning or evening as in the middle of the day.

Corsets should not be worn by children, and girls should wear an easy-fitting blouse or shirt and knickers suspended, like a boy's trousers, by straps over the shoulders; but "braces," strictly so called, "for improving the figure" should not be used.

Laundry Work in the Tropics.

Supervision of laundry work is a point with reference to clothing which receives too little attention in the tropics. In the East it is no uncommon thing to see clothes being violently beaten on stones, a process destructive to all fabrics, and notably so in the case of flannel.

In addition to the absence of all ordinary skill and care, the washing is carried out in any dirty stream or pool that may happen to be convenient, and in many places the washing is carried out in streams which, owing to their receiving the drainage of the city, are much polluted, and in this way handkerchiefs and other articles of intimate use become contaminated with bacteria.

The ironing and storage of the clean (?) clothes is usually as badly carried out as the washing itself. Too often the clothing is ironed in the bazaar, and stored a night or two in the washerman's living-room, before it reaches the owner's bungalow. This may account for some mysterious outbreaks of disease amongst the European communities in tropical towns.

CHAPTER VI

SITES, SOILS, AND HOUSES

THE requirements for a healthy tropical dwelling are seven in number—namely:

1. A soil suitable for building purposes.
2. A site which is dry and an aspect which gives light and cheerfulness.
3. A system of sewage removal sufficiently adapted to modern life to ensure speedy removal of noxious material from the environment of the residents.
4. Proper means for ventilation.
5. A proper system of construction which will ensure perfect dryness of foundation, walls, and roof.
6. Proper means of cooling the rooms in hot weather.
7. Efficient means of lighting.

How far tropical conditions depart from these requirements is obvious from the fact that in olden times it was the fashion in many parts of the East for each new king to build a new city. The custom no doubt originated from the fact that after a certain number of years a town became so unhealthy that it was advisable to leave it.

The insanitary conditions which still prevail in tropical cities are appalling. For example, Bombay, the commercial capital of Western India, with an area of 14,300 acres and a population of fully 1,000,000, is one of the most densely crowded cities in the world. All available building areas in the city have long been taken up for building purposes, and the vast majority of its residents live in tenements.

There are few open spaces in the shape of parks, *gardens, or other* places of public resort, to act as

"lungs" to the city. Extreme overcrowding exists in the tenement *chawls*, in which sometimes as many as fifteen to thirty persons sleep in each room at night, while in some of the large four and five storied buildings from 300 to 500 people have been counted.

Most of the Bombay tenements consist of very small, damp, ill-ventilated rooms. Their drains are faulty, and open into a dark, badly paved, badly drained, and narrow gully, reeking with all kinds of noxious odours and poisonous emanations from leaky privies. To a very large number of such residential quarters in the city these sweepers' passages constitute the chief, if not the only, ventilating space for the adjoining living-rooms, and some of them are filthy.

1. Soil.

The health of a locality is intimately connected with the nature of the soil on which its houses are built.

Absorption of heat, under otherwise similar conditions, is determined by the nature of soil and vegetation.

Sand is most absorbent of heat ; clay comes next ; then chalk ; and finally humus, or mould.

Trees and shrubs intercept the sun's rays, and, on the other hand, check evaporation from the surface of the soil, the net result being to render the ground cold and moist in winter, and cool and dry in the summer, when the leaves are out. The evaporation from leaves is very great, and tends to moisten and cool the air and abstract water from the soil.

Grass renders a soil cooler and more equable in temperature.

At a certain point below the surface is the subsoil water. Its level varies greatly. When the ground water rises it forces the air out of the soil, and at the same time may pollute wells by bringing into them the washings of impure soil. As the ground water falls again it *leaves the soil moist* and aerated—conditions favourable

for fermentation and putrefactive processes in organically polluted soil.

Experiments have tended to discredit previous reports that the enteric organisms can survive in soil for long periods.

Dampness of soil is favourable to phthisis and diphtheria, and, according to some authorities, to rickets. Goitre is, however, credited with a more indirect relation to the soil, and recent experiments tend to show that the causal agent lives in earth and passes by means of potable water to man.

Gravel soils are best for building purposes. Sandy soils are undesirable, unless covered with short grass. As turf is rarely seen in the tropics without irrigation and superabundant vegetation, the bare sandy soils which are common are very hot. Clay soils should be avoided, as they foster dampness.

2. Site.

It is essential always to build on the highest ground available, and invariably provide surface drainage, so as to prevent pools forming, which may become mosquito nurseries. The best site is a gentle slope on a gravel soil.

Marshy and swampy ground should on no account be used for building purposes, and what are called "made soils" must be especially avoided. Such sites consist of hollows filled up with rubbish of all kinds, and are obviously full of impurities which must and do produce emanations prejudicial to health.

3. Sewage and Refuse Disposal.

Sewage and refuse disposal are fully dealt with in the next chapter.

4. Ventilation.

Ventilation has already been dealt with in Chapter III., but the health officer must insist on an opening

2. **Selling by Tender Yearly.**—As town refuse is found to be a good top dressing for the production of grass, it will sometimes command a sale. This method commends itself to municipal authorities, as it enables them to get over a great difficulty without expense, and even with profit; but it is not to be recommended, as the contractor is very often dilatory and unsatisfactory in carrying out the process of removal.

3. **Destruction by Fire.**—This is far and away the best method, but the method of disposal in different districts has hitherto depended largely on local circumstances and conditions, the cheapest plan available having always the preference in the tropics. Oftentimes this may be but a mere makeshift, and the means of disposal for many years may be nothing better than a hunting about from one makeshift to another, until at last, all other means having been exhausted, a refuse destructor becomes an absolute necessity.

Given a good destructor and proper management, town waste and house refuse can be reduced to about one-third of their original bulk, the residue being innocuous clinker, metallic refuse, and dust.

The adoption of incineration of excreta has the advantage of rendering the disposal of other refuse comparatively easy, as destructors—of a kind—are always available.

Proper receptacles for refuse should be provided by all tropical municipalities. They should be small, covered, and made of some kind of metal, so as to be unabsorbent, and they must be emptied at least once daily.

Mortar.—Properly made mortar consists of lime with clean, sharp sand, but unfortunately, mud mixed with chopped straw takes its place to an alarming extent in the tropics; indeed, it is difficult to know what the native architect would do without this useful but sordid material.

Stone.—The rocks most commonly used in building are the sandstones and limestones, both of which are easily worked and plentiful in some parts of the tropics.

Bricks.—In India and other tropical countries bricks are of two kinds—*kutcha* and *pukka*. The former is made from mud dried in the sun, whilst the latter are made from "brick earth," which may consist of pure clay, clay loam, and clay marl. A brick should be well shaped, and all its angles should be right angles. The edges or solid angles should be sharp and clean. It ought to weigh 5 pounds, be twice as long as it is broad, and be homogeneous in character and colour, both externally and, on section. The common dimensions are 9 inches by 4½ inches by 3 inches. A brick can absorb as much as 1 pound of water, but if it absorbs more the builders regard it as "overthirsty."

Wood.—For structural purposes, deal, pine, teak, and in India the wood of the shisham, or *Dalbergia sissoo*, are chiefly used. The quality of timber depends on its rate of growth and its original position in the stem of the tree. The slower the growth and the nearer the centre of the tree, the better the specimen. A rough comparative test is the musical note given out by the wood when it is struck by a hammer. A good dense wood gives a clear ringing note.

No timber can withstand alternate wetting and drying, or heat and moisture, without adequate ventilation. Under such conditions decay sets in, especially if lime be adjacent; hence the ends of house-beams are liable to early degeneration. Two peculiar diseases affect timber—*namely*, dry and wet rot—the exciting cause

being fungi. Wood suffering from either form of rot must be removed, as it favours the development of wood-lice, and therefore sandflies. Protection from decay is best secured by forcing creosote under pressure into the wood, or, in the case of external woodwork, by painting and varnishing.

Plaster.—The best quality consists of lime or cement bound up with sand and hair; but the lime plaster generally used in the tropics consists of bricks ground up with lime.

Walls.—The walls, for purpose of stability, must rest on a broad base. These broad bases are called the "footings," and rest upon the foundations. In heavy or main walls they must extend on both sides of the wall, and must project on each side to a distance equal to one-half the thickness of the wall. It is most important that foundations should be of the best material, as work is very apt to be scamped when hidden. Concealed parts of walls are similarly likely to be neglected, and therefore wainscoting, or lining with wood, is most undesirable in the tropics.

Damp-Proof Courses.—As water can rise in the house walls by capillary attraction to a height of 32 feet, it is essential that moisture interceptors be placed in them. These are called "damp-proof courses," and may consist of Portland cement, glazed stoneware, slates embedded in cement, or tarred bricks.

In a properly constructed house one damp interceptor is required where the footing ends and the wall begins; a second 6 inches above the level of the external earth; and as damp may enter the wall from above, a third on the very top, beneath the roof timbers. If only one damp-proof course is feasible, it should be placed in the second position.

Papering the inner or room walls of a house in the tropics is to be deprecated. Paper is expensive, and cannot be often renewed. Moreover, one of the greatest

enemies of the mosquito is the biennial colour-washing, which ensures the brushing down of bungalow walls at least every six months.

All sharp angles should be rounded off, to facilitate cleanliness and prevent deposits of dust.

Walls should invariably be coloured in the lightest shades—*e.g.*, rose colour—as we shall see mosquitoes dislike all the lighter colours.

Chimneys.—The flues should be straight, circular, separate from each other, and smoothly lined, so as to prevent the risk of fire, facilitate cleaning, and aid the upward draught. All chimneys should rise at least 3 feet above the roof.

Roof.—There should always be an open space between the ceiling of the highest room and the roof. Tile roofs are very common in the tropics. They harbour rats, and thus tend to spread plague. The tiles are good conductors of heat, and in the absence of a properly constructed ceiling and air space a room may be rendered absolutely uninhabitable by the heat radiating from a tiled roof.

Double roofs of non-conducting materials and high rooms are essential to comfort in the tropics. The heat radiated from a roof is in inverse ratio to the square of its distance. The direct heat reaching a person from a roof 5 feet above him is four times as much as would reach him if the roof were 10 feet above him. Ceilings should always be insisted on, as they act as powerful heat interceptors. The air space between them and the roof should always be ventilated.

Thatched roofs, consisting of palm-leaves or bundles of long wiry grass laid on a bamboo frame, are very cool and dry; but, unfortunately, they are very inflammable, and harbour squirrels, rats, and insects, and other animals. Plantain fibre forms a good roofing material, and is not inflammable, but requires frequent repair.

Corrugated or galvanized iron is used as roof coverings

ever, more serious, and cannot be regarded as satisfactorily met by the proposition for a minute and detailed autopsy in every case. The discovery of organic disease would not necessarily exclude the possibility of foul play, and an examination sufficiently detailed to exclude every known poison is obviously impracticable. Exhumation is rarely resorted to, but the possibility of it acts as a check upon crime.

As practised by the poorer classes of Hindus, however, cremation is by no means a good plan of disposal of the dead. Fuel is expensive, and very often the dead Hindu is taken to the burning ghat, and his face merely burned with fire; the body is not burnt thoroughly, because of the poverty of the relatives or the greed or dishonesty of the people paid to carry out the cremation.

The partially charred body is usually thrown into a river. If the deceased has died of a disease such as cholera, the danger to the riparian villages and towns is obvious.

3. **Exposure.**—In some parts of the tropical world bodies are simply exposed to the elements, and their ultimate disposal left to scavenging birds. The *dakhmas*, or towers of silence, of the Parsees have frequently been described, and are looked on with something like horror by Western people; but they are far from being insanitary, and have never been shown to spread infection.

The platform on which the dead are laid is lined with marble or concrete, and channels are provided for the collection and disposal of fluids which may escape from the bodies.

The corpses are picked clear of flesh in a period ranging from a few hours to a week.

The dry bones are then placed in a large pit, where they gradually undergo resolution into a fine, impalpable powder.

This method, though contrary to European and even

most Oriental sentiment, is well adapted to the tropics, as it is rapid and effectual.

The favourite method of Eastern criminals of disposing of the bodies of their victims is to throw them down a well—preferably, of course, one not in use. Dead bodies of animals are frequently disposed of in the same way, but more often they are deposited on the village refuse-heap, producing one of the most offensive of many insanitary abominations to be seen in the vicinity of tropical towns.

common disease in the tropics, the parasite is charged with conveying leprosy and skin diseases.

2. *The Ixodidæ* (*Ticks*).—These pests are the agents for the conveyance of a large number of diseases of animals, and it has been shown that they convey the germ of the Central African form of relapsing fever.

THE INSECTS, OR HEXAPODA.

The insects constitute a zoological class, divided into twelve orders and numerous families. The only orders which contain vectors of disease are:

1. Diptera, including flies of all kinds.
2. Hemiptera, including bugs.
3. Anoplura, including lice.
4. Siphonaptera, including fleas.
5. Hymenoptera, including ants.

The bodies of insects are covered with a tough skin, and are divided into three distinct parts: (1) The head, provided with two antennæ, or horns, and eyes and mouth of variable form; (2) the thorax, composed of three segments, which has underneath it always six articulated limbs, and often above it two or four wings; and (3) the abdomen, composed of nine segments, some of which may be difficult to recognize.

In addition to these characteristics, they are not provided with interior skeletons and the nervous system is formed of a double cord, swelling at intervals, and placed under the head and lungs; they breathe by particular organs, termed "tracheæ," extending parallel to each other along each side of the body, and communicating with the exterior air by lateral openings, termed "spiracles." The sexes of all insects are distinct, and are reproduced from eggs. Finally, in many cases the different parts we have mentioned are not complete *until the tiny* creature has passed through the following *four stages*, called "complete metamorphosis":

1. The egg stage, in which the insect usually attracts no attention.

2. The larval stage, in which it is most destructive as a maggot, grub, or caterpillar.

3. The nymph stage, in which the insect again becomes inoffensive.

4. The imago, or stage of full development.

THE DIPTERA.

This order is characterized by:

1. A single pair of membranous wings
2. A suctional mouth.
3. Complete metamorphosis.

The members of this order with which we are concerned are divided into three groups:

1. Group A: Containing mosquitoes, sand-flies, and midges.

2. Group B: Containing the great family of house-flies.

3. Group C: Containing the large family of horse-flies.

GROUP A.

General Characteristics.—Flies with slender bodies and long antennæ, which are often plumed.

The group includes the most important disease-transmitting insects—viz., mosquitoes, sand-flies, and midges.

1. **Culicidæ.**

Family Characteristics.—(1) A proboscis; (2) scales on wings, head, thorax, and abdomen; (3) venated wings. No other flies except Psychodidæ have scales on their wings, and the short proboscis of the Psychodidæ, as well as their general appearance, is quite distinctive. Chironomidæ, which are much like mosquitoes, have not got a long proboscis.

Subfamilies :

(1) Culicinæ.
(2) Anophelinæ.

The first three stages of all varieties are spent in the water, the last only on the wing.

(1) *Culicinæ.*

Life-History—The Imago: Male.—Antennæ more plumose than female; palpi prominent in both sexes.

Female.—Antennæ shorter than proboscis, and have only short lateral hairs. Head scales: (1) Narrow curved; (2) upright forked; (3) laterally few flat scales. The scales on the wings, head, and body have frequently characteristic shape in the different species and genera, and are therefore used in classification.

The head contains organs of sense and a brain.

The chest is chiefly filled with muscles which move the legs and wings, and the abdomen contains the more important organs of digestion.

The legs are made up of hips, thighs, shanks, and feet, and the tip of each foot is a sharp-pointed claw.

The wings are generally larger in the female than in the male, and vary greatly in colour. They may be brown, grey, or greenish-black, and have scales with various delicate markings, utilized to distinguish the different species.

Eggs.—To deposit her eggs, the insect alights on a floating fragment in weedy, stagnant water, forms her hind-legs into a receptacle, and drops her eggs one by one on to it.

The eggs are oval in shape, and about 1 millimetre in size, surrounded by a gelatinous material which binds them together. They adhere together in little raft-like colonies, containing two or three hundred eggs, which float on the surface. Found in artificial collections of ter—*e.g.*, rain-tubs, cisterns, and old tins. They are *nestic breeders.*

Larva.—In about three days the egg opens by a sort of trap-door near the larger end, and the larva, which is just big enough to be macroscopic, comes out under water. From the first it swims about actively.

It consists of a head with two very large eyes, a globular thorax, and an abdomen of nine segments.

The last two segments of the abdomen are of curious construction. The eighth bears gill processes, and the ninth is prolonged upwards into a breathing tube or siphon, at whose summit the tracheæ open.

The end of the tube is surrounded by a fringe of fine hairs, which prevents it from sinking and the opening of the tracheæ from being submerged. The culicine larva spends a considerable part of its life thus suspended by its siphon fringe to the surface film of the water, but if frightened, or desirous of feeding at the bottom, it can shut up the fringe, and its own weight causes it to sink.

The larva is very voracious, and is continually on the move in search of food, which consists of small aquatic plants and animals.

The larva is preyed upon by small fish, and, to avoid its natural enemies, has a great predilection for aquatic weeds, which provide it with grateful protection. It sheds its own skin two or three times, and grows rapidly.

Nymph.—The change from larva to pupa is very rapid. The full-grown larva swims about in a fitful, purposeless way, and finally comes to rest. It then sheds its skin, and emerges as a perfect nymph.

The pupa, or nymph, is a comma-shaped creature, with long, narrow siphons projecting from the posterior portion of the thorax.

When about two or three days old, the nymph case, which is at first light in colour and difficult to see, develops silvery patches, due to bubbles of air underneath them, then splits, and the perfect insect emerges

from it. It raises itself on its legs, withdraws its wings, and, standing on the buoyant pupa case, lifts itself well into the air, and, when its wings have sufficiently hardened, flies away.

Culex fatigans.—Very common tropical mosquito. Carries: (1) *Filaria bancrofti*; (2) "dengue probably"; (3) *Plasmodium præcox* (bird malaria).

Mansonia uniformis.—Tropical Africa, New Guinea, and Australia. (Tibiæ banded.) Carries *Filaria bancrofti.*

Stegomyia.—A variety of Culicinæ. They have the following scales on the head:

1. No narrow curved scales.
2. Few forked upright scales.
3. Flat scales covering whole of head.

Stegomyia fasciata v. ædes calopus.—(Thorax two median yellow lines and lateral curved silver lines. A speckled mosquito.) Carries: (1) Yellow fever; (2) *Filaria bancrofti*; (3) dengue.

(2) *Anophelinæ.*

The members of this subfamily constitute the malaria carriers. Theobald divided the anophelines into more than twenty genera, distinguished by different scale marks. Only the following tropical varieties have been shown to carry the disease:

North America: *A. maculipennis* (commonest European carrier).

South America: *Cellia albipes* (West Indies); *C. argyrotarsis* (Brazil); *M. lutzii* (zygotes).

Malaya: *A. maculatus, A. albirostris.*

Africa: *M. funesta* (commonest African carrier); *P. costalis* (common African carrier); *A. maculipennis, A. algeriensis, M. hispaniola* (the last three in Algeria); *Cellia pharoensis* (zygotes).

India: *M. culicifacies* (commonest Indian carrier); *M. listoni, N. fuliginosus, A. stephensi, A. theobaldi.*

Fantham, Stephen, and Theobald give the following table of the anophelines which act as malaria carriers :

°*Anopheles maculipennis*, Meigen.
Anopheles bifurcatus, Linnæus.
°*Myzomyia funesta*, Giles.
Myzomyia lutzii, Theobald.
°*Myzomyia rossii*, Giles.
Myzomyia listoni, Liston.
Myzomyia culicifacies, Giles.
Pyretophorus superpictus, Grassi.
°*Pyretophorus costalis*, Loew.
Pyretophorus chaudoyei, Theobald.
°*Cellia argyrotarsis*, Robineau-Desvoidy.
Myzorhynchus pseudopictus, Grassi.
Myzorhynchus barbirostris, Van der Wulp.
Myzorhynchus sinensis, Wiedemann.
Myzorhynchus paludis, Theobald.
Myzorhynchus mauritianus, Grandpré.
Neocellia stephensi, Liston.
Neocellia willmori, James.
Nyssorhynchus theobaldi, Giles.
Nyssorhynchus fuliginosus, Giles.
Nyssorhynchus annulipes, Walker.

Those marked with the asterisk (°) also carry the larvæ of *Filaria bancrofti*, as also do *Myzorhynchus minutus*, Theobald, and *Myzorhynchus nigerrimus*, Giles.

The reader is referred to Section xxxii., pp. 136-144, "Aids to Tropical Medicine," for further details regarding this subfamily.

Imago.—Sex distinguished as with Culex.

Proboscis straight, and palpi as long, or nearly as long, as proboscis. They are rural breeders.

These two characteristics are present only in female anophelines. Wings spotted in most varieties, but *A. bifurcatus* of Salonika and *A. lukisii* of Mesopotamia have clear wings.

Eggs.—These are readily distinguished from Culex eggs, as they are found separately on the surface of water, or arranged in triangles or other geometrical figures; boat-shaped, ribbed laterally; found in natural or terrestrial collections of water.

Larva.—The attitude on the surface of water is characteristic.

An anopheline larva, instead of lying with its head and body sloping downwards beneath the surface in an oblique direction, lies flat on the surface, nearly the whole of its body lying parallel to and touching the surface film. There are two reasons for this attitude—namely: (1) Anopheline larvæ do not possess the characteristic air-tube of the Culicinæ; and (2) on the upper surface of the abdominal segments are little cup-shaped structures called "palmate hairs," which open at the surface of the water, and, acting like floats, keep the body of the larvæ in contact with the surface. These palmate hairs can be easily seen by examining in a drop of water under a low power of the microscope. They are not present in the larva of any other kind of mosquito, and, together with the straight and short air-tube, render anopheline larvæ easy to recognize.

An anopheline resting on a wall usually assumes a characteristic attitude. It rests on its first two pairs of legs, and keeps the last pair stretched out. Its body forms an angle with the wall, whereas in most other varieties the body is held parallel to the surface, or the tail is tucked in, giving the insect a "hunchbacked" appearance. Too much importance must not be attached to this fact, as the commonest malaria carrier in India—*M. culicifacies*—looks exactly like a small brown Culex as it "sits" with its body parallel to the resting surface.

Nymph.—It is not easy to distinguish anopheline from Culex nymphæ, but the matter is not important.

The Biting Parts of the Mosquito.—The organ of

special interest to the health officer is the proboscis of the anopheline. It differs considerably in the male and female.

In the female it consists of gutter-shaped lower lip (the labium), roofed in by the upper lip, composed of labrum and epipharynx, so as to form a complete sheath and support for the inner parts. These consist of a flattened, blade like "hypopharynx," or tongue, and four sharp serrated needles—the two mandibles and maxillæ. It is these last six parts of the organ which do the actual work of piercing and sucking. The epipharynx and hypopharynx form by their approximation a central tube through which the blood is sucked.

The labium does not pierce the skin at all, but can be seen to bend, so as to allow the labrum to be inserted to a satisfactory depth. Attached to the end of the labium by a hinge-joint on either side are two leaf-like processes—the labellæ. It is through the angle made by two labella that the stylets pass, as a billiard cue between the thumb and the index-finger. The labium proper stops short at the point of junction of the labellæ. Between the labellæ there is a projection of the labium connected with them by a thin membrane—Dutton's membrane—which is stretched during the act of biting. Through this membrane filarial embryos escape from the interior of the labium. The labium itself encloses a cavity, so that there are two tubes in the proboscis—the blood-sucking tube described above, and the other lying in the hypopharynx, which is the salivary duct. The first is afferent, the second efferent.

In the male the labrum and hypopharynx are fused together. The mandibles are absent.

Habits of Mosquitoes.—Water is an absolute essential to the development of mosquitoes, especially stagnant water or the edges of marshy pools. A puddle is not essential for the development of the nymph, as a moist

piece of ground does equally well; but actual dryness is fatal to mosquitoes in all stages of development.

The staple fare of both sexes is the juice of vegetables, but the female prefers blood when she can get it, and the blood of birds and mammals is as greedily devoured as that of man.

Mosquitoes can be kept alive in captivity for several weeks on bananas, but the desire for blood is so strong that it is asserted they will even bite a corpse.

In cool climates the mosquito becomes lethargic, and either goes back to vegetarian habits or hibernates in barns or cowsheds. Larvæ will remain for two or three months without any development if kept cool.

Mosquitoes in various stages of their development can live for many months and withstand long periods of cold.

With the exception of the Stegomyia, they are, as a rule, energetic only at sunset, but in darkened rooms they are common enough in the day; hence our frequent recommendation in previous chapters that all tropical rooms should be brightly lighted. If disturbed, they will bite at midday even on sunny winter days.

The humming and buzzing noise made by mosquitoes varies with the sex and with the species of the insect. It is produced by the vibration of the wings and a special organ. The wings produce the deeper notes and the special organ the higher ones.

The pain of mosquito-bites is not due to the bite itself, but to the poison which is injected when the insect bites.

It is generally said that this poison is instilled to produce irritation, and thus attract more blood to the part.

This can hardly be the case, as the bite is a distinct disadvantage to the biter.

The true reason is that the poison has the power of keeping the blood liquid, and thus rendering it more suitable to the digestion of the insect.

2. Simuliidæ (Sand Flies proper).

The Simulium is a little humpbacked fly, which in some parts of America does great damage to live-stock, and even to dogs and cats. The males are harmless, but the female sucks blood. Eggs are deposited in gelatinous masses on water-weeds and stones.

The larvæ live in quickly running water, and are peculiarly adapted for this mode of life, as they have a sucker at the end of the body, which enables them to cling to stones. Moreover, they are able to spin threads, which anchor them to suitable projections in the stream.

The fly does not come to the surface to be born from the pupa, but emerges under the water, and floats to the surface protected by a bubble of air entangled amongst the hairs of the legs and body.

3. Psychodidæ (Owl Midges).

Subfamily: Phlebotominæ, Genus Phlebotomus.

The other insect known by the name of "sand-fly" is the owl midge. This variety is like the other in appearance, but is more hairy.

There are several species—*e.g.*:

1. *Phlebotomus papatasii.*
2. *P. molestus.*
3. *P. minutus.*
4. *P. babu*, and others.

General Appearance.—Small yellowish-brown flies from $1\frac{1}{3}$ to 2 millimetres in length (size of an ordinary pinhead), with the body and wings densely clothed with long hair. Antennæ palpi, and legs long; proboscis straight, projecting vertically beneath the head; abdomen of the female roseate when full of blood.

Breeding-Places.—Crevices in rocks and caves, dirty cellars, damp places containing rubbish, crannies and crevices in walls.

Eggs.—Deposited in hole bored in detritus of wood louse and lizard by proboscis of female.

(1) *Colour.* — Opalescent white at first, becoming brown. Surface reticulated.

(2) *Number.*—Thirty to thirty-five.

(3) *Size.*—36 by 12 microns.

Larva.—Thirteen segments. Head distinct. Mouth parts on central surface. No eyes. Has only prolegs. Body covered with spines. Two tail hairs at first, four later.

Larval Life.—Lasts about sixty days.

Pupal Life.—Twelve days.

Flight.—The flight is strong, forward, and undulating. The last characteristic enables an observer to follow the flight across a well-lit room. Its distance is about 50 yards.

Life-History.—The insect hibernates in the larval stage. The larvæ creep under detritus, and lie almost motionless, feeding for days when the surroundings are favourable; but excess of moisture causes them to begin to crawl about.

Food-Supply.—Detritus, which appears to consist of wood louse and lizard excreta, is the chief food-supply. At birth larvæ will also eat the hairs off the body of a dead fly. They are also cannibals, two or three attacking a weak one, and devouring all but the caudal hairs.

Habits.—The Phlebotomus has a remarkable habit of hopping sideways, and is hard to catch on this account. Is an evening flyer. Attacks wrists and ankles. Vanishes at sunrise.

They are able to shoulder their way through a mosquito-curtain; the front pair of legs is first passed through, by which means the meshes are separated and a hole is made big enough to allow the fly to pull itself through.

Food.—The female alone is a blood-sucker. No male has ever been seen biting, nor has one been observed containing blood. Both sexes appear to drink water and to suck moisture.

Sand-flies can be exterminated by measures which deprive them of breeding facilities—viz.:

1. Good walls to houses.

2. Painting or distempering instead of whitewashing walls.

3. Good floors and disuse of matting.

4. Removal of old walls and ruins.

5. Frequent use of formalin spray on walls.

6. Removal of all old woodwork, and painting and varnishing of all doors, etc., yearly.

Personal protection comes under two headings:

(*a*) The use of a fine-mesh mosquito net, twenty-two meshes to the inch.

(*b*) Where a net is not available, various insectifuge preparations—*e.g.*

(i.) Bamber oil (*vide* p. 180).

(ii.) Equal parts of ung. ac. boric., ung. zinc. ox., and ung. eucalyp. with calomel, gr. v. to x. to the ounce.

Rub over exposed parts.

In hot weather, when sleeping in the open, if the bedstead is placed on gravel or sand, sand-flies may keep one awake the whole night, but if the bedstead is placed on the grass, these insects give little if any trouble; advantage should also be taken of any breeze, which effectually limits the activities of these pests. It is possible that these small flies are concerned in the spread of Oriental sore, caused by a protozoan parasite.

Lieut.-Colonel J. Mackenzie, R.A.M.C., writes: "Bamber oil and bed-over-grass saved me many a sleepless night in the Afghan War of 1919."

4. Chironomidæ (Midges).

Sometimes midges are confused with mosquitoes, but may be distinguished by (*a*) short proboscis retracted under cowl-like thorax, (*b*) small head often, (*c*) absence of scales and different arrangement of veins on the wings. *In resting* attitude the midge raises its fore-legs

above the head, whereas mosquitoes raise the hind-legs above the rest of their body. Only the subfamily Ceratopogoninæ suck blood.

Appearance.—Extremely small flies, not exceeding 1½ to 2 millimetres in length. Males are usually somewhat larger than females, and have tufted antennæ.

Colour.—Blackish or dark greyish-brown. Abdomen of female often rosy, owing to contained blood.

Wings.—Wings closed one over the other, like the blades of a pair of scissors, when at rest; often hairy, and frequently speckled with greyish-brown blotches.

Eggs.—The eggs of aquatic species are laid in floating algæ in star-shaped clusters containing from 100 to 150.

Larvæ.—The larvæ of naked-winged species of Cera topogon are aquatic, those of hairy-winged species terrestrial.

1. *Aquatic.*—The larvæ are whitish, worm-like creatures with long, narrow heads. They live in the masses of confervæ floating on the surface of stagnant pools and ditches. They are without prolegs on the prothoracic segment, and progress with a serpentine motion.

2. *Terrestrial.*—The larvæ of the hairy-winged species live under the damp bark of dead trees, in weeping spots on tree-trunks, and in decaying vegetable matter generally, such as manure, rotting fungi, etc. These terrestrial larvæ are usually shorter than the aquatic ones, and do not move in serpentine fashion, but are provided with a cleft proleg on the under side of the prothoracic segment; while the head and the body segments also bear peculiar lancet-shaped hairs and spines.

Nymph.—The nymph, which is shorter than the larva, with a conspicuous pair of respiratory horns on the thorax, is brownish in colour, possesses little power of movement, and remains at the surface of the water.

GROUP B.

General Characteristics.—The group consists of a large family of insects of the familiar shape of house-flies, and having a proboscis that may be short or long, but is always polished in appearance.

The following species are found from time to time in houses in the tropics :

1. *Musca domestica* (house-fly).
2. *Fannia canicularis* (lesser house-fly).
3. *Fannia scalaris* (latrine-fly).
4. *Stomoxys calcitrans* (stable-fly).

The *Musca domestica* is a medium-sized greyish fly, with its mouth parts spread out at the tip for sucking up liquids. It breeds in a great variety of substances of a filthy nature, and is found in practically all parts of the world. On account of the conformation of its mouth parts the house-fly cannot bite.

Several kinds of metallic green or bluish-coloured flies are occasionally found in houses—*e.g.* :

5. *Calliphora vomitoria* (bluebottle-fly).
6. *Lucilia* spp. (greenbottle-fly).
7. *Sarcophaga* spp. (flesh-fly).

The most abundant of these is the so-called "bluebottle-fly." This insect breeds in decaying animal material.

These three classes of flies are responsible for the cases of cutaneous or external myiasis (*vide* Epidemiological Table, Appendix) which have long been familiar to tropical practitioners, and have been met with in France and elsewhere during the Great War.

In most parts of the world the house-fly prefers to lay its eggs upon horse-manure, this material being its favourite larval food ; but this substance is not always available for it in the tropics, where in many parts every scrap of manure is made into cakes and used as fuel. In warm climates the fly develops a taste for human

excrement, and is very partial to fruits of various kinds. It is therefore a constant menace to the health of human beings, carrying the germs of intestinal diseases, such as enteric fever and cholera, from excreta to food-supplies, on its body, wings, and legs, also by passing the organisms through its intestinal tract. It will also lay its eggs on any decaying vegetable and animal material, but of the flies that infect tropical houses a vast proportion comes from either human excrement or horse-manure. As the fæces dry and crumble, the maggots bury themselves in the earth, finding a passage by way of cracks and the holes made by worms or dung-beetles.

The excrement of dogs has also been found to serve as a breeding-place for various flies which haunt houses and hospital wards. Cow-dung and the earth under it harbour fly maggots, but experiments have shown that house-flies do not breed in ordinary ground as distinguished from organic deposits.

To attract the house-fly, ordinary house refuse must be in a state of fermentation, as flies breed in relatively small numbers in refuse where fermentation has not taken place. They do not breed at all in receptacles which are emptied at short intervals, but the use of disinfectants, as ordinarily carried out, does not prevent them breeding in such receptacles unless they are regularly emptied. Very dry or excessively wet ashes or moist cow-dung does not harbour them.

The presence of fowls, but not ducks or geese, reduces the number of larvæ and pupæ in stable litter to a very marked extent, and there are certain species of ants which destroy them with great rapidity.

The duration of the egg state of the house-fly is twenty-four hours, the larval state from three to five days, and the pupal state from five to seven days.

The periods of development vary largely with the climate and season. Aldridge gives the following table *for India:*

Stage.	*Hot Weather.*	*Cold Weather.*
Eggs	One day	Two days
Larvæ	Five days	Fourteen days
Pupæ	Three days	Five days

The insect hibernates in the pupal form in manure, or at the surface of the ground under a manure-heap. In the adult form it also hibernates in dark nooks and crannies in houses. The unceilinged roofs of tropical bungalows and native houses offer limitless facilities for flies to enjoy undisturbed winter repose.

The number of eggs laid by an individual fly averages about 120, and the enormous numbers in which the insect occurs is thus plainly accounted for, especially when we consider the universal presence of appropriate food.

A number of experiments have been performed to see how far *Musca domestica* can fly, but they are not satisfactory. It is believed that a female fly becomes sexually mature and deposits ova in ten days after leaving the pupa case, that she lays four batches of eggs at intervals of ten to fourteen days, and that she then dies, but these figures must be received with great caution. Jephson believes that the limit of life of an adult fly is three weeks, but a hibernating or æstivating fly must live much longer. Indeed, a fly has been known to live sixteen weeks.

Their fecundity, the rapidity with which one generation succeeds another, and their great voracity, added to the extraordinary quickness of their production, are such that Linnæus tells us that three flies, with the generations which spring from them, could eat up a dead horse as quickly as a lion could!

The presence of flies in a house means that filth is near at hand.

Austin's table shows clearly the characters of the two chief varieties of house-flies, and also that of *Stomoxys calcitrans* (stable-fly), now indicted with Tabanus for conveying infantile paralysis.

Preventive Measures against Flies.

A. Natural Enemies.

1. Fungi (*e.g.*, *Empusa muscæ*).
2. The centipede.
3. Certain beetles.
4. Certain varieties of ants.
5. Spiders, toads, lizards, and rats, which are expert fly-catchers.

B. General Preventive Measures.

1. *Prevent fly-breeding* by prompt removal of all refuse, especially stable litter and manure. Abolish all possible breeding-grounds. Manure is best (1) burned, (2) buried), or (3) tightly packed.
2. *Protect all food and latrines* by screens, nets, etc.

Fly Destruction.

Measures designed to deal with the adult fly can only be regarded as secondary to those which aim at the abolition of breeding-places :

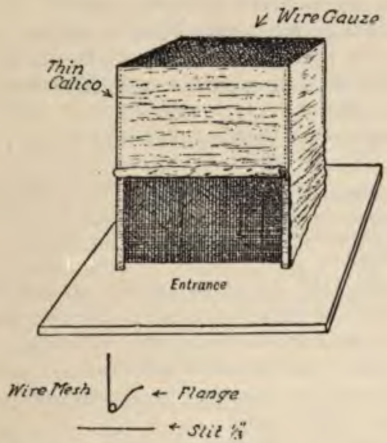
1. Swatting.
2. Fly-papers.
3. Fly-traps.
4. Poisons.
5. Fly-sprays.

1. *Swatting.*—A certain number of flies may be destroyed by "swatting." The best form of swatter is made of flexible wire gauze with a fine mesh.

2. *Fly papers*, tapes, and wires should be coated with *sticky material*, which may conveniently be made from :

Resin	62 parts.
Castor oil	26 ,,
Honey	12 ,,

The resin is crushed and heated with the castor oil in a water-jacketed receptacle. It should be thoroughly mixed, and painted whilst still hot on to wires with a hook at one end and a cork at the other. The proportion of constituents required varies with the temperature, but a good mixture should pull out into a string 12 inches long when cold.



BALFOUR'S FLY-TRAP.

Wires which have become covered with flies should be passed through a flame, and then recoated.

Fly-papers catch best when placed in an arched position with the sticky side uppermost.

3. *Fly-traps* are very useful in hot countries. A trap should be well lighted, so that after partaking of the bait

the fly may be attracted into the upper part of the trap and remain there. Traps may be baited with jam, marmalade, milk and sugar, cheese and sugar, vinegar, bread and sugar, rum and treacle, or chicken's entrails. It is well to vary the bait and position of the trap from time to time. The catch may be destroyed by means of heat or a poison bait (sodium arsenite).

Fly-traps should be placed on the sunny side of a cookhouse and sheltered from the wind.

Many kinds of traps have been invented, varying in size from the small balloon trap to the large Balfour trap, but all depend upon the same fundamental principles for success.

4. *Poisons.*—For general use the best poison is formalin.

Formalin	½ ounce.
Sugar	¼ ,,
Lime water	½ pint.
Water	½ ,,

The mixture is placed in saucers around the room with an island of bread upon which the flies may alight. All other liquid must be rigorously excluded.

5. *Fly-sprays* can be used with success where flies congregate in the evening. Army fly-spray (diluted 1 to 20 in water) is useful.

Spraying with pyrethrum powder in methylated spirit is best done in the evening.

If there is no filth, there will be no flies.

Group C.

This group includes: (1) Tabanidæ; (2) Glossinæ.

Tabanidæ.—Majority of blood-sucking Diptera belong to this family.

Appearance.—Generally rather large, flat-bodied flies, with broad head and eyes coloured with green or purple bands or spots. Antennæ point straight ahead, rather variable in shape. Coloration sombre. Wings tectiform, banded, and notched.

Breed mostly in mud at edges of streams and ponds. Development requires about two months, often longer.

Brues and Sheppard associate Tabanus with Stomoxys as vectors of epidemic poliomyelitis.

Glossinæ—*Appearance.*—Brownish colour, 7 to 12 millimetres long. Wings close like scissors; venation characteristic.

Hard chitinous proboscis ensheathed in palpi; has onion-shaped bulb.

Arista is a fine bristle-shaped process feathered on upper side only.

The female produces a single yellowish larva at a time, which is retained and nourished within the oviduct of the mother until full-grown, and on being extruded at once crawls away, and turns into a pupa as soon as it finds a suitable hiding-place. The pupa is dark brown, with a pair of prominent granular protuberances at the posterior extremity.

Glossina palpalis is the chief carrier of the *Trypanosoma gambiense*, the cause of sleeping sickness.

THE HEMIPTERA.

The only family of hygienic interest is the Acanthiadæ (Cimicidæ), which includes the genus Cimex or bed-bug.

Two varieties attack man—viz.:

1. *Cimex* (*Acanthia*) *lectularius* (common bug of northern latitudes).

2. *C. rotundatus* (bug of the tropics).

Appearance.—The body is soft, oval, about ⅕ inch in length, of a reddish-brown colour, and covered with a little hair.

Eggs.—The eggs are laid in crevices or cracks in the floor or furniture in batches of twelve to fifty. They are beautifully shaped and sculptured, and the young escape by a round door at one end about five to ten days after they are laid.

Nymph.—The young are similar to the adult, but are smaller, more transparent, and less darkly coloured. There are probably five moults, and if the insect is under favourable conditions, where it can get blood easily, the whole life-history will probably not occupy more than two months. A meal of blood seems to be required before each moult and before egg-laying, and if it cannot be obtained the interval between moults may be very greatly prolonged.

Habits.—The adult insect feeds about once in from thirty-six to forty-eight hours, taking nearly fifteen minutes to get its fill of blood. At earlier ages the feeding period is much shorter.

It is nocturnal as a rule, but active at all times.

It abounds in dirty houses, principally in towns of warm climates. It lives in beds, woodwork, behind pictures, under matting and carpets.

Distribution.—Almost world-wide, as it is readily carried in steamers, and can survive for long periods, even as long as two years, without food (F. V. Theobald). This accomplishment enables it to live from season to season in hill bungalows, empty hotel apartments, and the like.

C. rotundatus transmits leishmaniasis, according to Rogers and Patton,* and probably cerebro-spinal meningitis and typhus fever.

Preventive Measures.—1. Fumigation with formaldehyde, HCN gas, or sulphur.

2. Cleanliness.

3. Washing the floor and wooden bedsteads with kerosene-oil emulsion.

4. The use of pure pyrethrum powder.

5. The leaves of the *Pterospermum acrifolium* are used in India as a preventive against night attacks.

Natural Enemies.—Cockroaches and small red ants.

* "Scientific Memoirs," Government of India, No. 50.

THE ANOPTERA.

This order includes the Pediculidæ, or lice family, which are closely allied to the bug tribe. Three species infest men—viz. : (1) *Pediculus capitis*, the head louse ; (2) *P. vestimenti*, the body louse ; (3) *Phthirius inguinalis*, the crab louse.

1. Pediculus capitis.

Appearance.—Of greyish colour, with a flat, slightly transparent body. It is spotted with black on the spiracles, soft in the middle, and rather hard at the sides. The head is oval, and furnished with two thread-like antennæ, composed of five joints, which are constantly in motion whilst the creature is walking. Its eyes are black, round, and of simple structure. In front of the head is a short, conical, fleshy nipple. This nipple contains the sucker, or rostrum, which, when extended, represents a tubular body, terminating in six little pointed hooks, bent back, and serving to retain the instrument in the skin. The organ is surmounted with four fine hairs fixed to one another. It is by means of this complicated apparatus that the louse pricks the skin of the head. The limbs are thick, terminating in a strong claw, which folds back on an indented projection, forming a sort of pincer. It is with this pincer that the louse fastens itself to the hair.

Eggs.—White and barrel-shaped. Deposited on the hair, and are commonly called " nits."

No metamorphosis occurs. The young are hatched in the course of five or six days, and in eighteen days develop full sexual powers. It has been calculated that in two months two female lice produce 10,000. Naturalists have asserted that a second generation of a single individual can amount to 2,500, and the third to 125,000.

2. Pediculus corporis (vestimentorum).

The body louse is larger than the head louse.

3. Phthirius pubis (inguinalis).

The crab louse is found on the pudenda. It is very readily communicated from man to man. Eggs often laid singly, attached to hairs near the apex.

Relapsing, trench, and typhus fevers are conveyed by pediculi.

Destruction of Lice.

For the head louse, when the condition is very bad, the hair should be cut *short*, as it is difficult to destroy thoroughly all the nits. Repeated saturation of the hair with turpentine or with carbolic acid lotion.

Where possible, blankets should always be disinfested, but if facilities are not sufficient to disinfest both clothing and blankets at one time clothing must be given preference. It is useless to disinfest blankets without at the same time disinfesting all clothing. Similarly, it is useless to bathe and cleanse without at the same time disinfesting all clothing.

Many men acquire tolerance towards lice-bites after they have been infested for a couple of months, and experience no particular discomfort from the presence of the insects.

Dissemination of Lice.

Lice are spread mainly through contact with verminous persons, more especially when men are huddled together in billets and dug-outs. They tend to wander when men's surroundings are warm and comfortable—for instance, when men are sleeping closely crowded together. The high temperature of people with fever is repellent to lice, and they wander away in search of more congenial surroundings. In this lies the danger of approaching too closely to lice-infested cases of typhus or relapsing fever. Lice forsake dead bodies, as they can no longer extract blood from their hosts.

Lice may also be disseminated amongst men by contact with verminous clothing. Stray lice may be also picked up in railway carriages and other places frequented by verminous persons. Blankets, too, ordinarily appear to be only a subsidiary source of infestation. These modes of dissemination are negligible compared to that from man to man, especially when they are crowded together in warm surroundings.

Lice like a temperature of about 90° F. At temperatures lower than this they become sluggish and feed less frequently ; at the freezing-point they are immobilized and cease feeding. At temperatures slightly above 90° F. they become extremely active, and endeavour to escape to cooler surroundings. They die in a short time at 112° F., and temperatures a few degrees higher are rapidly fatal. When separated from the host, lice very soon starve to death ; young lice die in one or two days. When lice-infested clothes are laid aside, the lice cannot in any circumstances survive for more than nine days, and commonly not so long. This does not apply to the eggs, which, as already stated, may remain alive for longer periods, even several weeks, but clothes stored for about three months are sterile. Billets, trains, dug-outs, etc., do not usually harbour lice, and may be regarded as uncommon sources of infection.

Scrupulous cleanliness is sufficient to prevent recurrence. In the case of the body louse, the clothing should be disinfested by steam, hot air, or baking. To allay itching, a warm bath containing 4 to 5 ounces of bicarbonate of soda is useful. The skin may be rubbed with a lotion of carbolic acid containing 2 drachms of pure carbolic acid and 2 ounces of glycerin to the pint of water. For the crab louse the parts should be thoroughly washed two or three times a day with soft soap and water, and unguentum hydrargyri ammoniati or unguentum hydrargyri applied.

Nits are removed by soaking the hair in 10 per cent. vinegar, followed by the diligent use of a fine comb.

THE SIPHONAPTERA (PULICIDÆ).

Two chief subfamilies :

1. Pulicinæ.
2. Sarcopsyllinæ.

Fleas were originally flies, and had wings, but their form and structure has in the course of ages become profoundly altered in consequence of their parasitic habits.

Pulicinæ.

General Characters.—Small head, well-marked eyes : eggs unlike those of pediculi, not fixed to hairs.

Chief members :

1. *Pulex irritans* (*Human Flea*).—Large size, brightly coloured, eyes distinct. Found in dark and dirty habitations, usually on man only. No bristles behind head, but bristles on posterior extremity of abdomen. Claws large and scythe-like.

2. *Xenopsylla cheopis* (*or pallidus*).—Rat flea of the tropics. Resembles *P. irritans,* but is smaller in size and more brightly coloured. Loves the dark, and is very sensitive to light. Claws small and sickle-shaped.

3. *Pulex serraticeps* (*or felis*).—A small flea of dark colour. Not nocturnal in habits. Lives on dog, cat, rat, man, and monkeys. Has combs behind head, but no bristles around mouth.

Pulex Irritans.

Body is oval, somewhat flattened, and covered with a hard, horny skin of brilliant chestnut-brown colour. Head is small in proportion to its body. There are two small jointed antennæ of cylindrical form. The eyes are simple, large, and round. The rostrum is composed of an exterior jointed sheath, having inside it a tube, and

carrying underneath two long, sharp lances with saw-like edges.

The quantity of blood absorbed is enormous compared with the size of the insect.

Limbs are long and strong. Foot has five joints, and terminates in hooks turned in opposite directions. Two anterior limbs are separated from the others, and are inserted nearly underneath the head; the posterior ones are particularly large and strong. The jumps of the flea are gigantic, and its strength herculean, when compared with the size of its body.

Eggs.—The eggs, about twelve in number, are oval, smooth, and white. They are laid singly on the ground, between the boards of floors, in old furniture, on rugs, or amongst dirty linen and rubbish. Mixed with the eggs is usually some dried blood, provided by the mother for nourishing her young.

Larva hatches out in fifty hours to five days in tropical climates. It is of cylindrical form, covered with hair, and divided into three parts, the last being provided with two small hooks. The head is scaly above and has two small antennæ, and is without eyes. These larvæ have no legs. Though at first white, they soon become a reddish colour.

After about a fortnight they spin a cocoon, inside which they are transformed into pupæ, and in another fortnight these pupæ become perfect insects.

The insect is most abundant in dirty houses, deserted buildings, ruins, and in places frequented by people of uncleanly habits.

Xenopsylla Cheopis.

The rat flea is essentially a parasite of the rat, but it does not confine its attacks to these animals, and it will bite man, especially (but not only) when there are no rats on which it can feed. It is well known that before plague attacks men of a village the rats in the place

usually die of the disease. When the rats die, the rat fleas leave their bodies, and then are particularly liable to bite men, and thus infect them with the plague bacillus which the fleas have previously sucked up with the blood of the rats on which they last fed.

Iodoform is said to be a most efficient means of banishing fleas; a trace of this drug on clothes is sufficient to keep all fleas at a distance. It should therefore be a valuable prophylactic in plague-infected districts.

2. Sarcopsyllinæ.

General Characteristics.—Head large and forehead angular; thorax narrow.

The only member of this variety of interest to tropical hygienists is *Dermatophilus* (*Pulex*) *penetrans*, the chigger or sand-flea.

This insect is not unlike the common flea, but is smaller in size. It is flat, brown in colour, with a white spot on the back, and is armed with a powerful rostrum composed of a long epipharynx prolonged from the pharynx. It is hollow, but there is no opening at its extremity. The under-surface is grooved, and continuous with the wall of the pharynx. The mandibles are grooved on the mesial surface. In the act of biting the epipharynx and mandibles are driven into the skin, and the approximated mandibles form a passage down which the salivary secretion is forced; and blood is sucked up, not along the same channel, but along an upper channel formed by the approximation of the epipharynx and the two mandibles.

The maxillæ are not utilized in biting, and the labium merely acts as a sheath, and is doubled back in the act as in the mosquito.

Its favourite haunts are dry, sandy soil, the dust and ashes in badly kept native huts, the stables of cattle, poultry-pens, and the like. It greedily attacks all warm-blooded animals, including birds and man.

The female, when impregnated, settles on the skin, and burrows in a slanting direction. It slips in between the flesh and the nails, or gets under the skin of the heel. The process does not cause any pain at first, but after a few days irritation appears, which, although at first slight, gradually increases, and ends by becoming unbearable.

The chigger, when under the skin, proceeds to ovulation, and in consequence becomes as large as a small pea. The skin over the surface may ulcerate and the chigger be expelled. This sometimes occurs before the eggs are laid, but more frequently afterwards. If the insect is not extruded before the time of laying eggs, these are expelled either through the small opening in the skin made by the insect when she entered, or through the larger ulcerated opening caused by the inflammation. In either case the eggs fall to the ground, and after a few days a thirteen-ringed larva is hatched out. This larva soon encloses itself in a cocoon and undergoes further development, and in from eight to ten days' time the imago emerges.

As the cause of suffering and disability, the chigger is an insect of some importance. It is now extremely prevalent on the East Coast of Africa, and causes a large amount of invaliding amongst Indian coolies.

THE HYMENOPTERA.

This order embraces some of the most interesting of insects, including bees and wasps; but the only members with which we are interested in relation to the transmission of disease are the Formicidæ, or ants.

These insects are, in general, small creatures of a brown or black colour.

Like bees, they are social insects. They live in communities in which there is a considerable amount of specialization of forms to serve the purpose of useful *division of labour*. Their little republics consist of

males and females and various forms of workers, but the degree to which this specialization goes varies very much with the species. Commonly there are two or three forms of workers—the soldier, with a large head and mandibles; and the workers, major and minor, with more normal structure. A nest may consist of a greater or smaller aggregation of individuals, and there are a few species which share the light-shunning habits of the white ants; but most varieties nest in soil, trees, etc., and work in the light.

In general the ants are scavengers, the workers bringing to the nest the food for the whole community. This food consists of dead insects and other animal matter, the sap of plants, and any edible vegetable matter that can be obtained. In this sense ants are excellent scavengers, and as they are practically everywhere in the open, they serve an extremely useful function in the tropics.

Life-History.—The life history of ants is very similar to that of bees.

The eggs are laid by the female, and tended by the workers in the nest. The larva hatches out in about a fortnight, and is a white helpless grub, without legs and incapable of exertion, which is fed by the workers. In some varieties the pupæ are free, in others in silken cocoons which the larvæ itself prepares. The larvæ and pupæ live in specially built galleries in the ant-hills.

Hitherto only experimental evidence has been adduced against the ant as a disseminator of disease (C. Balfour). A species is said to render valuable service by destroying the eggs and larvæ of house-flies.

THE ARACHNIDA (SPIDER GROUP OF ARTHROPODA).

The Arachnida is a large group of Arthropoda con-*taining many* animals which differ markedly in their *structure one* from another. There are no true gnathites;

its appendage loses all other functions and becomes exclusively a jaw, although the proximal joints of several are prolonged inwards towards the mouth and help to take up food; in a word, some of the limbs have developed gnathobases. The most anterior appendages are never antennæ, but always a pair of nippers, termed chelicerræ. The active catching and walking legs of the fore-part of the body, or prosoma, are strongly contrasted with the plate-like modified limbs of the middle part of the body, or mesosoma, when the latter exist, but in many cases these have disappeared, and in others have become so modified that they are no longer recognizable as limbs. In the marine and some land varieties the breathing apparatus consists of gills. In other land forms tracheæ assist the respiratory chambers, and in still others entirely replace them. The gills have a peculiar form found only amongst Arachnida. They consist of "books" of thin superposed lamellæ attached to the posterior aspect of an appendage. When modified for breathing air these "books" are called lung-books. When, as is the case in Limulus, they breathe oxygen dissolved in water, they are called gill-books. Many different orders are included in the Arachnida, the best known being perhaps those which include the spiders, the harvestmen, the mites, and the scorpions.

The members known to affect man are not numerous—viz.:

1. Sarcoptes Scabiei.

This member of the tribe produces scabies. The male lives on the surface of the skin, is rarely found, and dies soon after mating. The female has a pearly white colour, and can be seen with the naked eye. It makes for itself a burrow in the skin forming the web of the fingers and toes, backs of the hands, armpits and penis in men, and breasts in women. As many as fifty eggs are laid in a burrow, and then the tunnel becomes the *arachnid's grave.*

The lesions which result from the presence of this parasite are very numerous, and arise largely from the scratching which it induces, and from too vigorous use of sulphur or beta-naphthol in treatment.

Like the *Demodex folliculorum*, it has been accused of acting as an agent for the dissemination of leprosy, so that its early destruction is especially desirable in the tropics.

Some idea of the rapidity with which itch parasites multiply may be gathered by the following table, prepared on the assumption that a single female deposits fifteen eggs which develop into five males and ten females :

Generation.	*Days.*	*Females.*	*Males.*
First ...	15	10	5
Second ..	30	100	50
Third ..	45	1,000	500
Fourth ...	60	10,000	5,000
Fifth ...	75	100,000	50,000
Sixth ...	90	1,000,000	500,000

2. Demodex folliculorum.

This Acarina lives in the sweat glands at the roots of hairs and in diseased follicles in the skin of men and some domesticated animals. The diseased follicles become filled with fatty matter ; the upper end becomes hard and black, forming what in man are known as "blackheads." If one of these blackheads is forced out and the fatty substance dissolved with ether, the mites may be found in all stages of development. The young have six legs and the adult eight ; the body is elongated and transversely streaked.

"Si le demodex de l'homme est une simple curiosité *sans importance* au point de vue médical, il n'en est pas

de même du *Demodex folliculorum* var. *caninus* et du *Demodex phylloïdes*, Csokor, qui déterminent, l'un chez le chien, l'autre chez porc, des affections cutanées très graves et extrêmement tenaces, connues sous le nom de gale folliculaire" (Dubreuil et Beille).

It has been observed that the *Bacillus lepræ* is often closely associated with these face mites, and it has been asserted that they are concerned in the spread of leprosy,

3. The Ixodoidea (Ticks).

These little animals constitute a large family of the order Acarina, and play an important part in the transmission of disease. They are widely distributed, many animals having special species of their own, and are always visible to the naked eye. They are non-vegetarian and blood-suckers.

They are divided into two families:

1. Ixodidæ.
2. Argasidæ.

Distinguishing Features.—The Ixodidæ only moult twice during their lives—viz., at the change from larva to nymph, and from nymph to adult; the Argasidæ moult not only at these periods, but also several times during the adult stage. The Argasidæ also do not become distended with blood to the enormous extent so characteristic of the Ixodidæ.

Appearance.—Vary greatly in size. Usually yellow in colour when young, deepening to dark brown in the adult stage.

The head, thorax, and abdomen are fused together. The Ixodidæ have a dense chitinous plate called the "scutum," covering in the male the whole, and in the female a portion, of the dorsum. This is absent in the Argasidæ. Eyes are present in some varieties, absent in others.

The organs chiefly concerned in biting are the hypo-

stome—a conspicuous dagger-shaped process, with a number of teeth directed backwards and arranged in rows—and the mandibles, or cheliceræ, which are very powerful, and carry a jointed process, the digit, which bears large hooked teeth.

In Ixodidæ the females are almost invariably larger than the males, and in some species, when gorged with blood, may reach a length of nearly ½ inch. In Argasidæ the sexes differ very little in appearance. As a rule they are temporary parasites, but some live in a quasi-permanent manner on the body of their host, and a few burrow beneath the skin.

After fertilization the male dies, but the female attaches herself to her host, and proceeds to gorge herself with blood for the development of her ova. Becoming enormously distended with blood, she drops off, and secretes herself in some nook or cranny, where she deposits her eggs, which are small, yellowish, roe-like grains. Each female lays several thousands of eggs, and occupies some weeks in the task. After a period varying from a few weeks to several months, the eggs are hatched out on the ground. The hexapod larvæ look like grains of sand. These minute creatures crawl to the summit of a blade of grass, and there await for weeks or months the passage of some animal to which they can cling.

They live on the animal for a few days, and then fall off, developing on the ground, first into the nymph, which is octopod like the adult, and later (with or without the intervention of a second host) into full-grown individuals of both sexes, which get on the body of an animal and mate. The female then falls off and lays eggs, which in due course develop into larvæ and start the cycle anew.

The tick may convey disease in any of its stages of development, and some varieties lay eggs which produce larvæ which are infective.

The duration of life is probably a year or more, but on account of the difficulty of finding an appropriate host, ticks are endowed with a phenomenal capacity for fasting, and they have actually been found alive after a fast of four years.

The tick lives in native huts. It is nocturnal in its habits, hiding during the day in cracks in the walls and floors, or in the thatched roofs. It feeds slowly, and is unable to get much blood from any but sleeping persons.

Ornithodoros savignyi, found in Somaliland and other places where *O. moubata* is absent, probably acts as a transmitter of relapsing fever (Drake-Brockman). "Ulcers" and a severe form of fever which is common in Southern India are popularly attributed to *O. savignyi*.

The most important member of the Ixodoidea is the African tick. *Ornithodoros moubata* has been proved to be the disseminator of a variety of relapsing fever known as "coast" or "tick" fever. It can also carry *Filaria perstans* (Christy).

RATS.

Rats are found everywhere in the tropics, and, apart from the amount of damage done by them to property, Kunhardt estimates that their food bill in India during the last two decades amounts to £200,000,000. They are very prolific, producing several litters of eight to ten young per annum, but their multiplication depends largely on the accessibility of food.

The part played by rats in the spread of disease is important. The rat is—(1) the most effective agent in the spread of plague; (2) the primary host of *Trichina spiralis;* (3) the cause of rat-bite fever; (4) the reservoir of spirochæta-ictero-hæmorrhagiæ; (5) a host of *Tænia nana*; (6) a possible carrier of equine influenza.

The Muridæ are a family of the Rodentia, and include the *genus Epimys,* to which belong both rats and mice.

Two species carry plague—viz., (*a*) *Epimys rattus* and (*b*) *E. norvegicus*.

(*a*) *Epimys rattus* (Syn. *Mus rattus*).—The common Indian house-rat and "plague rat" of Upper India. Slender, with very pointed muzzle and large, outstanding ears, prominent eyes, long tail, and greyish-black fur.

The tail, which is brown and regularly annulated, is longer than the length of the head and body together. Feet comparatively long and slender.

Length of body variable (about 15 centimetres). Colour brown on the dorsum, white or grey underneath. There are two to three mammæ.

There are two varieties of this rat—viz., *alexandrinus*, the larger, and *rufescens*, the smaller—with numerous intermediate species. It breeds frequently throughout the year.

It is essentially a house-rat, preferring to live in tiles or thatch, or in holes and recesses in the floor, but it will also take up residence in cocoa-nut trees.

(*b*) *Epimys norvegicus* (Syn. *Mus decumanus*).—The brown, sewer, or ship rat probably came from China to Europe, and returned from Europe to India. Is the "plague rat" of Bombay. This species is a large rat, with short, round ears and broad, heavy snout. Colour: brown on the dorsum, with dirty white belly. The tail is thick and tapers uniformly. It is dark-coloured dorsally, lighter underneath, and shorter than the length of the head and body together. Feet are heavy, and flesh-coloured.

Rat Destruction.—Three methods—viz., (1) Hunting, (2) trapping, and (3) poisoning, which includes: (*a*) Gases, (*b*) viruses, (*c*) drugs.

(1) Hunting and (2) trapping only require a passing reference.

(3) Poisoning—(*a*) *Gases.*—Hydrocyanic acid is very effective, as it kills females and litters in their nests, but

is dangerous. SO_2 is the most generally applicable and least dangerous gas. Can be generated by Clayton's apparatus.

(*b*) *Viruses.*—These are now generally discredited.

(*c*) *Drugs.*—There is no poison in existence which will kill rats only (Rabinger). The following are the desiderata for a good rat poison : (1) Relatively harmless to domestic animals. (2) Cheap and readily procurable. (3) Reasonably small doses must kill for certain. (4) Tasteless. (5) Easy to handle and readily mixed with a bait. (6) Keep well and retain its toxicity.

Only two agents need be considered—viz., barium carbonate and squills. Barium carbonate ($BaCO_3$) and red squills (*Scilla maritima*) are largely used, but neither is ideal. The former satisfies (2) and (6) of the above desiderata, but is more toxic to other animals than is sometimes recognized.

Extract of squills is less toxic, but rapidly deteriorates. It keeps better if heated, and is best used as paste on moist bread, biscuit, or cheese.

CHAPTER X

ANIMAL PARASITES

IN the whole range of his duties, there is no subject of deeper interest to the health officer in the tropics than the relation of animal parasites to disease.

The animal kingdom is divided into two subkingdoms—viz., Protozoa, which are unicellular, and Metazoa, which are multicellular.

Only the Protozoa are dealt with in this chapter.

PROTOZOA.

The Protozoa consist of a single cell with distinct cytoplasm and nucleus. There may be colonies of cells, but there is no tissue formation.

Reproduction may be asexual, by fission ; or sexual, by syngamy.

The Protozoa are divided into four classes :

1. *Sarcodina*, composing those forms which have the general characteristics of Amœbæ.

2. *Mastigophora* or *Flagellata*—*i.e.*, forms having flagella.

3. *Sporozoa*—those forms which are rarely amœboid, and which multiply by sporulation.

4. *Infusoria*, in which the body is always corticate, and the organs of locomotion are always cilia.

Class I.—Sarcodina.

Organisms of this class include the Amœbæ, which are of interest in that many of them are parasites of the

human intestine, in which they may be non-pathogenic, *e.g.*, *Entamœba coli*—or pathogenic, *e.g.*, *Entamœba histolytica*.

Amœbic Dysentery.

Amœbic dysentery and its sequela, abscess of the liver (tropical liver abscess), are due to *Entamœba histolytica* (*Loeschia histolytica*).

The Amœbæ gain entrance to the body in food or water, and set up inflammation of the intestinal tract affecting chiefly the colon (colitis). While the usual result of the presence of active forms of *Entamœba histolytica* is to give rise to acute diarrhœa, with the passage of blood and mucus, it should be borne in mind that extensive damage to the mucous membrane of the colon may take place without the characteristic symptoms, although abdominal pain is usually present, with dyspepsia and furred tongue, and in some cases low irregular pyrexia and slight diarrhœa without blood and mucus. In all such cases liver abscess is liable to follow.

Description of Entamœba histolytica.—The adult active form (vegetative stage) is found in the stools of acute and chronic cases. As seen in fresh specimens they are usually from 20 μ to 40 μ in diameter, highly refractile, and often show active movements. The protoplasm consists of an outer clear highly refractile layer of ectoplasm and a finely granular opaque endoplasm.

Red blood-cells in various stages of disintegration are frequently seen included in the cell. Movement is due to the throwing out—often with suddenness—of pseudopodia, which consist of ectoplasm only.

The nucleus can with difficulty be seen in a healthy Amœba, but becomes readily visible when degeneration is taking place. It is spherical, usually eccentric, and appears as a finely beaded ring from 4 μ to 7 μ in

diameter. A central dot—the karyosome—may frequently be seen.

There is a precystic stage, in which the Amœbæ decrease in size (minuta).

There is also a cystic stage, the cysts being from 7 μ to 20 μ in diameter, with nuclei varying in number from one to four. The nuclei are not easy to make out in healthy cysts, but can be readily seen in those that are degenerating.

In salt solution cysts appear as round or oval bodies, with a cyst wall which is thin, colourless, and has a double contour.

In preparations stained with iodine the cysts are of a yellowish colour, the nucleus showing as a beaded ring with a central dot—the karyosome. Ill-defined brownish patches of glycogen may be visible.

The precystic and cystic stages are found in carriers, also in cases of amœbic diarrhœa, and in cases under treatment.

The precystic stage is most likely to give rise to difficulty; there is little or no movement, ectoplasm and endoplasm are not sharply defined, and there are no red blood-corpuscles included.

Entamœba histolytica has to be carefully distinguished from other organisms, cells, etc., occurring in fæces.

(*a*) Other Amœbæ—*e.g.*, *Entamœba coli*, *Blastocystis hominis*, *Endolimax nana*.

(*b*) Degenerate forms of the flagellate Trichomonas and cysts of Lamblia.

(*c*) Epithelial and endothelial cells.

Entamœba coli—(1) *Active Forms.*—Ectoplasm very scanty; endoplasm contains bacteria, yeast cells, etc., but no red cells; vacuoles are common; nucleus clearly visible as a beaded ring; movement slight or absent.

(2) *Precystic Forms.*—Usually larger than those of *Entamœba histolytica*.

(3) *Cysts.*—Larger than *Entamœba histolytica* (10 μ to

30 μ); nuclei larger, one to eight in number, usually eight.

Mode of Infection with Entamœba histolytica.—The vegetative forms are not resistant outside the body, and rapidly die out. The cysts, provided moisture is present, remain alive; they are found principally in the solid or semisolid stools of convalescents and carriers, who are therefore the chief source of infection. Such persons should never be employed in the preparation of food and drink.

Flies, wind, soiled paper from latrines, may all carry infection.

Flies take up cysts from infected fæces, and the cysts are voided in their excreta. Flies are, perhaps, the chief carriers of infection.

When cysts are swallowed, the cyst wall is dissolved by the digestive juices, and the contents divide up into small Amœbæ, which can set up the disease.

Amœbic dysentery is an endemic or sporadic infection, in the onset of which some unknown factor is concerned.

Healthy persons who have never been out of England may harbour cysts of *Entamœba histolytica*.

Class II.—Mastigophora.

Adult organisms of this class are provided with flagella one or more, which may be situated anteriorly (tractellum) or posteriorly (pulsellum).

In the cytoplasm there is a nucleus, or there may be two nuclei—a trophonucleus (macronucleus) for nutrition and a kinetonucleus (micronucleus) for movement.

Reproduction is by binary fission or multiple fission or within a cyst—usually multiple fission.

The structure and life-history of many of the Mastigophora are imperfectly known, and research is constantly bringing to light new features.

Included in the Mastigophora are the organisms which

give rise to leishmaniasis, trypanosomiasis, and spirochætal diseases.

Leishmaniasis.

The genus Leishmania was established through the discovery by Leishman in 1900 of the intracorporeal stage of the parasite of kala-azar.

Organisms of this genus live chiefly in endothelial cells, and also in the leucocytes of the blood of mammals. They develop into flagellate bodies when cultivated in suitable media.

Three species of Leishmania are found in man—viz., *Leishmania donovani* in kala-azar; *L. infantum* in infantile splenic anæmia; *L. tropica* in Oriental sore.

Kala-Azar.

Kala-azar is a subacute or chronic febrile disease, characterized by irregular pyrexia, great enlargement of the spleen and to a lesser degree of the liver, with anæmia and progressive wasting. Until recently it was fatal in nearly all cases, but it has been found that treatment by injections of tartar emetic or of sodium antimonyl tartrate (less toxic) provides almost certain cure.

"Leishman bodies" are found chiefly in the spleen, liver, and bone-marrow, in the endothelial cells of bloodvessels and lymphatics. They multiply by fission.

The trophonucleus or macronucleus is oval or circular, and is placed centrally or peripherally. The kinetonucleus is in the form of a short rod placed peripherally; it stains very deeply with Leishman's stain or with Giemsa.

Rogers discovered in 1904 that if material from an infected spleen is placed in sodium citrate solution and kept at 22° C., the parasites undergo rapid changes of *enlargement*, vacuolation, fission, and flagellation; the *flagellated* forms are actively motile; they have no

undulating membrane, and the flagellum is free and anteriorly placed (tractellum).

It is assumed that the flagellate form is that in which the parasite occurs in its other host, which is as yet unknown.

The disease set up by infection with this parasite is usually endemic and sporadic, but at times occurs in epidemic outbreaks, as in Assam.

Preventive measures await the discovery of the source of infection, but isolation of the sick and general hygienic measures are indicated.

Infantile Splenic Anæmia.

Mediterranean leishmaniasis is caused by infection with *Leishmania infantum*. It is similar to kala-azar in all its features, but occurs in children, and can be readily inoculated into dogs, whereas kala-azar occurs in young adults and is difficult to reproduce by inoculation into dogs.

The source of the parasite is unknown.

Oriental Sore.

Synonyms.—Delhi boil, Bagdad button, etc

This is a specific ulcerative lesion of the skin, due to infection with *Leishmania tropica*, which is morphologically indistinguishable from *L. donovani* and *L. infantum*.

The source of the infection is unknown.

TRYPANOSOMIASIS.

This designation includes all diseases caused by members of the genus Trypanosoma.

Trypanosomes are hæmo-flagellates; as found in the blood they are motile, fish-like bodies, possessing a macronucleus and a micronucleus, an undulating membrane, and a single flagellum; the flagellum arises close to the micronucleus, is continued along the margin of the undulating membrane, and may or may not be prolonged beyond the body as a free flagellum.

The great majority of trypanosomes are harmless; only a few are pathogenic.

Trypanosomes are found infecting mammals, birds, reptiles, fishes, and also smaller animals, such as leeches and Arachnida.

Their life-history has not been fully worked out, but comprises an alternation of generations and an alternation of hosts; one generation or cycle is usually completed in the vertebrate host, and the other in the alimentary tract of a blood-sucking invertebrate.

Multiplication is by fission; sexual forms have been described, but reproduction by syngamy has not been proved.

Sleeping Sickness.

Pathogenic trypanosomes produce in their human host a chain of symptoms comprising chronic fever, wasting, eruptions on the skin, enlargement of lymphatic glands, and œdema; later there may be meningitis and encephalitis, giving rise to the symptoms known as "sleeping sickness."

The trypanosomes can be found in the peripheral blood, but they are often scanty and may be overlooked. Cultural methods are useful in doubtful cases.

The African forms of sleeping sickness are caused by:

(1) *Trypanosoma gambiense.*—This trypanosome is from 13 μ to 36 μ in length, there being long, short, and intermediate forms. The vector is a tsetse fly, *Glossina palpalis*, in whose gut the trypanosomes go through a cycle of development, eventually passing forward into the hypopharynx. Long, slender forms pass back along the salivary ducts and reach the salivary glands, where they develop into short, stumpy forms, which alone are infective. In this way the tsetse fly becomes infective several weeks after sucking blood from an infected person, and it probably remains permanently infective.

(2) *Trypanosoma rhodesiense*, carried by Glossina mor-

sitans, in which it goes through a developmental cycle similar to that described above.

The South American variety of sleeping sickness is caused by *Trypanosoma cruzi* (*Schizotrypanum cruzi*), and is spread by the bug *Triatoma megista* (*Lamus megistus*). The disease may be acute or chronic.

"Sleeping sickness" is merely the terminal phase of human trypanosomiasis.

The mortality is high, but of recent years prolonged treatment, extending over months or years, with atoxyl combined with antimony salts has given good results.

Prevention of Trypanosomiasis.—As the spread of trypanosomiasis depends on the presence of the carrier insect, general prophylaxis is obviously a large subject.

Wide tracts of Africa are affected, and it has been shown that big game may act as reservoirs of infection. Personal protection against the bites of tsetse flies is the most obvious precaution.

Amongst other flagellates occurring in man may be mentioned *Trichomonas intestinalis* and *Lamblia intestinalis*, both of which are pear-shaped, actively motile organisms with several flagella. Both have been credited with the power to set up diarrhœa, but this has not been definitely proved.

SPIROCHÆTAL DISEASES.

Spirochætes are long, wavy, thread-like organisms. The cytoplasm consists of ectoplasm and endoplasm, and there is a chitinous periplast. The nucleus consists of transverse bars or rodlets of chromatin. The spirochætes proper are provided with an undulating membrane, while the treponemata have no undulating membrane. They are motile, and progress rapidly with a combination of corkscrew and undulating movements.

Relapsing Fever.

1. The European type, caused by *S. recurrentis*, conveyed by lice.

2. The Egyptian type, caused by *S. berbera*, conveyed by lice.

3. The Indian type, caused by *S. carteri*, conveyed by lice.

4. The African and Colombian type (*S. duttoni*), conveyed by the ticks *Ornithodoros moubata* and *Argas americanus* respectively.

The spirochætes of relapsing fever are found in the peripheral blood.

The disease is ushered in by a rigor and giddiness, generalized pains, and pyrexia. Prostration and delirium usually follow, and the liver and spleen enlarge. After five or six days there is a crisis, and the temperature falls to normal. After a week or so the first relapse takes place, to be followed after three or four days by a second crisis.

Other relapses may follow before convalescence sets in.

The prevention of relapsing fever consists of taking measures against lice and ticks. Personal cleanliness and absence of overcrowding are indicated.

Infective Jaundice (Weil's Disease).

This has recently been shown to be due to a spirochæte—*Leptospira icterohæmorrhagiæ*—found in the blood, urine, bloody sputum, and cerebro-spinal fluid. In this spirochæte the spirals are in close apposition, and one or both ends may be turned back like a hook. The intermediate host is believed to be the brown rat, *Mus norvegicus*, in whose urine and fæces the organism is found. The method of entry of the leptospira into the human body is as yet unknown. There is some evidence that entry may be through the naso-pharynx and skin abrasions; infected food and water have come

under suspicion, and the possibility of an insect vector should be kept in mind.

Prevention consists of disinfecting urine, fæces, and bloody sputum. Protection of food, destruction of rats, and general hygienic measures are indicated.

S. bronchialis has been described as a cause of bronchitis, and *S. urethræ* has been said to be the cause of acute urethritis. *S. vincenti* — along with fusiform bacilli, which may be a stage in its life-history —is the cause of Vincent's angina.

The Treponemata.—The treponemata are generally included among the spirochætes because of their similarity in general form, but they have no nucleus like that of the spirochætes, and the spirals appear to be fixed. Under the treponemata two diseases have to be mentioned—viz., syphilis, caused by *Treponema pallidum* (*S. pallida*), and frambœsia (yaws), caused by *T. pertenue*. These are delicate, spiral-shaped, motile organisms, 4 μ to 10 μ long in the case of *T. pallidum* and up to 20 μ in the case of *T. pertenue*. They are best seen by dark-ground illumination in fresh material, or by Fontana's method of silver staining.

The treponemata are found in the primary sores and in the secondary lesions; in syphilitic infants they are present in enormous numbers in the internal organs.

Infection in both diseases is acquired by direct contact.

Class III.—Sporozoa.

The sporozoa are endoparasitic protozoa forming resistant spores.

There are several orders of the sporozoa, of which the hæmosporidia are of the greatest importance. The hæmosporidia are parasites of either red or white corpuscles of vertebrates, with alternation of generations and alternation of hosts, the schizogony or asexual phase occurring in the blood or internal organs of some

vertebrate, while the sporogony or sexual phase occurs in an invertebrate, such as an insect or leech. The parasites of malaria belong to this order.

Malaria.

A disease that destroys many millions of people every year and checks the progress of man in many lands must always be of absorbing interest to the tropical hygienist. The researches into this subject and the problems connected with it would take up many volumes; only a brief sketch can be attempted here.

In the etiology of malaria three parasites are concerned:

1. *Plasmodium vivax,* the parasite of benign tertian malaria.
2. *Plasmodium malariæ,* the parasite of quartan malaria.
3. *Plasmodium falciparum* (*Laverania malariæ*), the parasite of malignant tertian malaria.

These all go through their schizogony or asexual stage in the red blood-corpuscles of man, and their sporogony or sexual stage in certain species of the various genera of anopheline mosquitoes.

The principal vectors of malaria are given on p. 127.

Only the female mosquito sucks blood. The male insect is a harmless vegetable feeder.

At the end of their developmental cycle in infected mosquitoes, which takes about twelve days, the parasites are found in the salivary glands and ducts of the insect as delicate fusiform bodies, called "*sporozoites.*" When the now infective mosquito bites a man, the sporozoites enter the red blood-corpuscles and in them develop into "*trophozoites,*" composed of cytoplasm and nucleus. A vacuole quickly appears and the trophozoite assumes a "ring form," absorbing nutriment from the red cell. As the parasites grow, particles of pigment—melanin or *hæmozoin*—appear, and pseudopodia are thrown out.

When fully grown the parasite ceases to be amœboid, assumes a rounded form, and is now called a "*schizont*." The nucleus divides up into a number of small nuclei, and around each of these cytoplasm is arranged. This is the "rosette" form. The small bodies composing the rosette are called "*merozoites*," each of which is free from melanin, which usually collects as a more or less central mass in the rosette. The blood-corpuscle now ruptures, and the merozoites, toxin, and pigment are liberated into the blood-stream. The merozoites are devoured by leucocytes, or penetrate fresh red corpuscles and repeat the cycle. The pigment is deposited in the spleen and liver, which increase in size and become darker in colour. When the parasites have multiplied and are present in large numbers the toxin begins to upset the heat-regulating mechanism, and rigors take place each time the red corpuscles rupture.

In the case of *Plasmodium vivax* (benign tertian malaria) the cycle from rosette to rosette takes forty-eight hours; in the *Plasmodium malariæ* (quartan malaria), seventy-two hours; while in the case of *Plasmodium falciparum*, of which there are two varieties, the cycle is completed in twenty-four or forty-eight hours (malignant tertian malaria).

When the disease is fully developed, quartan malaria is characterized by a rigor ("ague") every third day, with an apyrexial period of two days in between. This is the least serious form of malaria; although great enlargement of the spleen takes place in an untreated case, the disease is not fatal.

In benign tertian malaria the rigor takes place every other day; enlargement of the spleen is less marked, but if the infection is heavy, extensive destruction of the red cells takes place, the symptoms are more serious, and death is liable to follow. This is, however, a comparatively rare ending in the benign tertian variety, which is *not*, as a rule, a fatal disease.

Malignant tertian malaria is of much more serious importance. The pyrexia is often of an irregular and remittent type, and owing to the fact that schizogony of the parasites takes place chiefly in the brain and other organs, blocking of capillaries may occur and give rise to dangerous symptoms. The cerebral form of malaria, in which the capillaries of the brain are blocked with masses of dividing schizonts, is extremely fatal; coma sets in, and in the absence of proper treatment death results. Hæmorrhagic, dysenteric, choleraic, and pneumonic forms also occur, and are often fatal. In cases which escape these extreme symptoms, severe wasting and anæmia gradually develop, and a state of "cachexia" results.

Diagnosis.—The three cardinal points in the diagnosis of malaria are—(1) demonstration of the parasites in the peripheral blood, (2) periodicity of the fever, and (3) amenability to treatment by quinine. Of these the first is the most direct and satisfactory, but cases occur —especially in the malignant tertian variety—in which repeated examination of the blood fails to reveal parasites. In such cases, however, a relative increase in the large mononuclear leucocytes points definitely to a protozoal rather than a bacterial infection, and is of great assistance.

Periodicity of the febrile attacks, if clearly defined, is usually diagnostic.

In the absence of parasites and periodicity in a doubtful case it is unjustifiable to withhold quinine, which should be given by the mouth or, in the presence of serious symptoms, intravenously.

Proper doses of quinine will always arrest the fever— in benign tertian cases usually in three days or less, and in malignant cases in about five days.

The possibility of the infection being a mixed one should be kept in mind. In *all* cases of malaria blood-films should be taken on the twelfth or fourteenth day

after the first onset of fever, as crescents are always to be found in malignant tertian cases at that time, whether fever is present or not, and whether treatment by quinine has been practised or not. By following this as a routine measure in all doubtful cases the diagnosis can often be definitely established.

MALARIAL PARASITES IN THE BLOOD.

	Type of Fever.		
	Benign Tertian.	*Quartan Tertian.*	*Malignant Tertian.*
Name of parasite	*Plasmodium vivax*	*Plasmodium malariæ*	*Plasmodium falciparum*
Size of red cell ..	Always enlarged	Not enlarged	Cell smaller and often crenated
Colour of red cell	Pale, and stains paler	Not paler	Darker; "brassy bodies"
Shape of red cell	Frequently distorted	Parasite eventually fills cell, but does not distend it	Rosette often fills only half the red cell
Degenerative changes in red cell	"Schüffner's dots"; degeneration of the cell in all forms except young rings	No "Schüffner's dots"; red cell almost normal	Maurer's dots (coarse)
Movements ..	Amœboid movements very active (vivax)	Movements sluggish	—
Melanin	Light coloured (yellow)	Almost black	Abundant; dark mass (internal organs only)
Rosette	18 to 24 spores	8 to 12 spores	16 to 18 spores, often more (internal organs only)
Gametocytes ..	Spherical	Spherical	Crescentic, then spherical
Schizogony ...	Period of development, 48 hours	Period of development, 72 hours	Period of development irregular (24 to 48 hours)
Effect of quinine	Disease yields readily to quinine	Yields readily to quinine	More resistant to quinine

Class IV.—Infusoria.

Only one organism belonging to this class requires mention — viz., *Balantidium coli*, which occasionally causes dysenteric symptoms.

It is oval, 0·05 to 0·1 millimetre in length, with a bean-shaped macronucleus and a rounded micronucleus. It is covered with cilia; these are arranged in parallel rows, giving it a striated appearance.

This organism is constantly found in the rectum of pigs. It has a cystic stage, and the cysts are liable to be swallowed by man.

TABLE OF CESTODA AFFECTING MAN.

Name.	*Length.*	*Characteristics of Head.*	*Eggs.*	*Number of Segments.*	*Intermediary Host.*
1. *Tænia saginata*	15 to 20 feet	No hooklets; four suckers; no rostellum; $\frac{1}{12}$ inch in diameter	Oval; thick shell $\frac{1}{850}$ inch in short diameter	1,000 to 1,300 $\frac{1}{2}$ to 1 inch in length	Ox
2. *Tænia solium* ...	7 to 12 feet	Four suckers; double circle of hooklets; has rostellum; size of pin's head	Round; thick brown shell	700 to 800	Pig
3. *Echinococcus hominis*	2 inches	Only $\frac{1}{100}$ inch in diameter; 28 to 50 hooklets in two series; prominent crown surrounding rostellum	Spherical	4	Man
4. *Tænia* or *Hymenolepis nana*	$\frac{1}{8}$ to 2 inches	Four suckers; rostellum; single series of 22 hooks	Oval; thick unmarked shell 30 to 60 microns in diameter	170	Some insect or snail
5. *Tænia* or *Davainea madagascariensis*	4 to 8 inches	Rostellum and 90 hooks	In balls of 400	100	Unknown
6. *Tænia cucumerina*	6 inches	Club-shaped, with rostellum and 4 rows of hooks	Oval	70 to 80	Dog and cat louse
7. *Bothriocephalus latus*	27 feet	Ovoid; $\frac{1}{10}$ inch is diameter; no hooklets	Lid at one end; brown shell	3,500	Fresh-water fish

CHAPTER XI

THE PREVENTION OF MALARIA

MALARIA is chiefly a disease of hot climates, but it was at one time extremely common in Great Britain, as may be gathered from the fact that such great historical personages as King James I. and Oliver Cromwell, the Lord Protector, died of malaria. Indigenous cases are met with in the Fen district of East Anglia; numerous instances of the infection of persons who have never been out of England occurred in 1917 to 1919 in various parts of Great Britain, due doubtless to the influx of infective material in the form of returned soldiers with malaria from Mesopotamia, Palestine, and Macedonia (James).

The disease baffled all treatment until 1640, when the Spanish conquerors of Peru found a remedy for it in a certain bark which grew on the slopes of the Andes. A Spanish lady of rank, Countess del Chinchon, first brought the bark to Europe, and endeavoured to introduce it. So furious was the opposition to the "pagan" remedy that she was obliged to confine her ministrations to the peasantry on her own estate. About half a century later, however, the new remedy excited so much discussion, by the numerous cures it effected, that it was considered worthy of a special council of the Jesuits, who formally pronounced in favour of its use, thereby attaching to it the name of "Jesuit's bark." The enlightened Countess has attained immortality by attaching her own name, Chinchona, softened into "cinchona,"

and hardened into "quinine," to the greatest therapeutic gift of the gods to mankind.

No further progress was made until 1880, when Laveran, a French army surgeon, discovered certain minute parasites in the blood, which were subsequently shown to be the cause of malaria.

It was then observed that the presence of these parasites in the blood was invariably associated with mosquitoes, and, acting on the suggestion that the disease was propagated by them, mosquitoes which had bitten malaria-stricken patients were brought to England from Italy and fed on Dr. P. T. Manson and Mr. G. Warren (men who had never been out of England, and had never lived in a malarious district). After being bitten by the infected mosquitoes they developed typical attacks of the disease, and the malarial parasites were found in their blood.

An antimalarial campaign was then undertaken in Italy, and it was shown by practical experiments that by either (1) protecting the individual from the bites of mosquitoes, (2) exterminating mosquitoes, or (3) carefully treating all patients so that no opportunity may be offered to the parasite to enter the mosquito, the disease may be eradicated from a locality.

In Chapter IX. we describe the life-history of the mosquito, and in Chapter X. the rôle it plays in the propagation of malaria, but we may here summarize the facts as follows:

The following requirements are necessary for the spread of malaria: (1) Men with sexual form of the malarial parasite in their peripheral circulation (gametocyte carrier); (2) efficient anopheles hosts; (3) a susceptible population; (4) an atmospheric temperature above 60° F. (16° C.) (Still).

Certain animals also are subject to a type of malaria —*e.g.*, birds, bats, monkeys, dogs, sheep, horses, and cattle have their own type of the disease; in 1898 Ross,

in India, working with a malarial disease of sparrows (proteosoma), infected twenty-two out of twenty-eight healthy sparrows by mosquitoes.

Fermi and Koch showed that the malaria-like parasites of other animals are not infectious to' man, and that the three human species can only exist in man as intermediate host, and certain species of anophelines as definitive host.

It is clear from the evidence that we adduce in Chapter IX. that where malaria abounds it is absolutely necessary that there should be anopheles; but it does not necessarily follow that every place where this variety of gnat is found must necessarily be malarious.

The improvement in health of the Fen districts of England did not entirely depend on the extermination of mosquitoes, as at least three species of anophelines are still found in Great Britain—viz., *A. nigripes* in Epping Forest, and *A. bifurcatus* and *A. maculipennis* in certain other places.

The old observations about malaria are very easily explained by the mosquito doctrine.

Malaria has always been associated with high temperature and marshy places, which we have seen are necessary for the health of the mosquito.

The malaria mosquito is a night prowler, especially on warm, still nights, and flies low. Hence the ancient dislike of being out late at night in malarious districts, and the love of the natives resident on low-lying lands for houses built on piles, or in some way raised from the ground, and the necessity for Europeans in malarial regions to follow these elementary precautions.

Smoke and fire have always had the reputation of keeping off malaria in camps, because they are inimical to mosquitoes. Many natives also sleep with their blanket or sheet over their head, and, when without a mosquito-net, Europeans should do likewise.

The rapid growth of aquatic weeds is often attended

by the disappearance of larvæ from a pond, and consequently certain localities have seasons comparatively free from them.

This fact has been put into practice in prevention by planting a tropical aquatic fern called "azolla," which spreads so rapidly that stagnant and even running water is rapidly covered. The plan has been tried in India and elsewhere, but found useless, as the wind blows the plant apart, and larvæ breed in the interstices.

Fluctuation in the incidence of malaria in various countries, seasons, or years depends on a variety of influences.

1. Prolonged drought.
2. Heavy or unusual rainfall.
3. Prolonged high or low temperature.
4. Anything which upsets the static conditions of the district—*i.e.*, influx of heavily infected population, such as a group of harvest labourers; arrival of a regiment from England, coupled with a nidus of infected native children; or unusual prevalence of enormous numbers of anophelines brought by high winds, or from other causes.
5. Varying prevalence of the natural enemies of the mosquito.

Prevention of Malaria.

The prevention of malaria may best be considered under the following headings:

1. Protection of the individual (infected and non-infected), including segregation, screening, and active treatment of the infected. Removal of chronic carriers from endemic zone.
2. Destruction of anophelines and their larvæ.
3. Quinine prophylaxis, under which heading we may include quinine disinfection of the infected.
4. Good house, urban, and rural sanitation.

These are the cardinal principles.

1. **Protection of the Individual** against anopheles and their bites.

This method of prevention, the primary one, is defensive—*i.e.*, protection of the individual from mosquito-bites, and screening, active treatment, and segregation of the infected. The measures we can adopt are:

(*a*) Mosquito-proof houses.
(*b*) Mosquito nets.
(*c*) Mosquito-proof clothes.
(*d*) Agents to prevent mosquitoes biting.
(*e*) Avoidance of certain colours of clothing.
(*f*) Screening of infected.

(*a*) MOSQUITO-PROOF HOUSES. — Mosquito-proof houses are largely used in America and Italy, and even in some parts of the tropics. They are too costly for general use, but, failing actual mosquito-proof houses with copper wire (rust-proof) gauze screening, much can be done; for example, windows and doors can be protected by gauze (eighteen meshes to linear inch), and made to open outwards and to close automatically with spring hinges.

Mosquitoes prefer to bite on hot, still nights; therefore keep the air of rooms cool and on the move by means of punkahs and fans.

(*b*) MOSQUITO NETS.—These cost only a few shillings, and are our chief defensive weapon. They act in two ways: (1) By protecting individuals from contracting malaria; (2) by preventing patients suffering from malaria from becoming a source of infection to others. The size of mesh should be eighteen meshes to the linear inch; twenty-two meshes to the linear inch in sand-fly zones.

For the mosquito net to be of real use the bed should be broad, so as to leave a considerable space between *the sleeper* and the net. The sides and ends of the net *must be inside* the poles, and the lower border tucked

well under the mattress, not hanging on the ground. Where poles are not available the net may be suspended from nails in the wall, or in a tent by pieces of rope or tape fixed in the tent at points corresponding with similar ones in the top corners of the net. If the net is not wide, the lower 2 feet of the net should be lined with calico, which prevents mosquitoes getting at the parts of the body that come into contact with the net during sleep. It should always be let down in the afternoon and carefully inspected in a good light for mosquitoes and sand-flies. An excellent plan is to make a servant responsible that it is in good repair and free from insects. This is ensured by inflicting a fine for any insects found when the net is used. It should be stretched fairly tightly, so as to allow the perflation of air. On getting into bed the interior should be examined for any mosquitoes that may have strayed in, and any invaders must be captured and killed at once.

(*c*) Mosquito-Proof Clothing.—Very thin cotton clothing must not be used in the malarious season, as mosquitoes can bite through it. The feet and hands should be kept covered after sundown, and the favourite feeding-ground of the mosquito and sand-fly—viz., the legs and ankles—should be rendered inaccessible by wearing drawers and thick socks (the mosquito can bite through thin ones quite easily, especially when sitting at dinner and during the evening). Military men usually wear long boots instead of the more comfortable shoes. Use veils and gloves when out of doors after sundown. Avoid night journeys, and camps under trees and foliage and near marshes, river-beds, or low-lying grounds.

(*d*) Agents that prevent Mosquitoes biting—*Culicifuges or Deterrents.*—Many and various chemical and mechanico-chemical agents and essential oils have been used as an application to the skin of the face, neck, hands, and other exposed parts, to keep off mosquitoes. The following are some of those recom-

mended: Oil of eucalyptus, oil of bergamot in kerosene (1 in 16), bamber oil, oil of rosemary, oil of aniseed, cassia oil, citronella oil in vaseline, oil of cloves and vaseline, kerosene oil, and even a saturated solution of magnesium sulphate.

Oil of citronella in the form of bamber oil (citronella, 1½ parts; kerosene, 1 part; coconut oil, 2 parts) is well spoken of by some authorities in East Africa and India. It is pleasant, harmless, readily procurable, and more durable than many others advocated.

The cheapest and not the least efficacious application is kerosene oil and lanoline. Much as a mosquito dislikes it, a hungry female will, however, feed off a surface coated with it.

The deterrent action of these culicifuges against other biting insects, such as sand-flies, midges, etc., as well as mosquitoes, is partly due to the pungent and penetrating aroma, and partly to the vehicle, which is more efficient as an ointment with vaseline and lanoline than in liquid or oily solution, because the thicker the vehicle, the more lasting it is and the less liable to be washed off by perspiration.

With all these applications, as soon as the volatile part of the oil, essence, or ointment has partly evaporated, mosquitoes will assuredly begin their attacks. They are only, as a rule, effective for the first twenty minutes, and then must be reapplied; therefore only of temporary use, and can never replace mosquito nets. They merely lull to false security, with the result that one may fall asleep, to be assailed by anophelines, and possibly be infected with malaria, while asleep. When really hungry, mosquitoes will overcome their distaste for all such applications, especially if the vehicle is thin and oily.

(*e*) AVOIDANCE OF CERTAIN COLOURS.—The colours blue, dark red, brown, and black are much more attractive to mosquitoes than white, grey, green, violet, and yellow. They should therefore be avoided, and only

white garments worn in malarious regions. The curtains on bungalow windows should be light-coloured or white, and not heavy and dark. There should be no heavy hangings round beds, rooms should be well lighted after dark, and if possible a current of air should be provided, either natural or artificial, by punkahs or fans. The dark, still area under a dinner-table is a favourite mosquito haunt.

(*f*) THE SEGREGATION (BY SCREENING) OF THE INFECTED.—All persons infected with malarial parasites are active agents of the disease and essential to its spread; but, unfortunately, the segregation measures we can adopt against them are not numerous, especially as the children of the poorer classes, who are the most prolific sources of malaria, cannot be isolated (see also Quinine Disinfection, p. 194).

Isolation and protection by mosquito nets of malarial cases are carried out in hospitals in India and elsewhere as a general measure of protection. Segregation is, as a rule, impracticable; but malarial patients must be kept under mosquito curtains—at any rate, whilst suffering from malarial attacks and with the malarial parasite in the peripheral blood—and be thoroughly treated with quinine. The removal of chronic malaria carriers from the endemic area by invaliding is an important military measure.

Every European in the tropics should endeavour by the administration of quinine and use of mosquito nets to limit the number of cases amongst his personal servants; for if one or more of these are infected, their proximity renders him and his neighbours liable to infection through the mosquitoes they infect. In a general way it may be said that when malarial fever occurs in a European he has acquired it from mosquitoes which have previously bitten an infected native, who is more often than not one of the victim's own servants or a child in his compound.

2. **Destruction of Anopheles and their Larvæ.**—This is a matter of the utmost importance. Mosquitoes and their larvæ may be destroyed by:

(*a*) Measures against the adult mosquito.
(*b*) Measures against larvæ.

(*a*) MEASURES AGAINST THE ADULT MOSQUITO.—(1) Clear away brushwood and long grass in the vicinity of dwellings, which should be located some distance from belts of shrubbery and trees. The clearing of grass and brush destroys resting surfaces, and shade from the sun during the daytime, as the mosquito cannot live long exposed to the sun.

(2) Fumigate native houses and all outhouses, particularly cattle-sheds, periodically during both winter and the malarial season.

In houses the adult mosquito must be destroyed either by burning pyrethrum powder (2 pounds per 100 cubic feet), vaporizing cresol ($4\frac{1}{3}$ ounces per 1,000 cubic feet), by sulphur fumigation (1 to 2 pounds per 1,000 cubic feet), or spraying with formalin. These metheds are always useful and necessary in regions where mosquitoes are numerous, in addition to destroying the breeding-places of anopheles. After fumigation of a building, all mosquitoes should be swept up and burnt, otherwise stupefied ones may recover.

N.B.—Formalin is preferable to sulphur, owing to the liability of the latter to tarnish native brass cooking utensils.

Even in winter the bulk of the mosquitoes in farm-houses and in cattle-sheds are practically all hibernating *females*, the dangerous or infective agent or vehicle. There is no reason to doubt that malaria can be maintained through a winter as cysts in the stomach of mosquitoes, quite apart from human carriers, and then *continue* development when the temperature conditions become more favourable. Particularly suitable hiber-

nating quarters are cattle barns and byres ; hence the necessity for attacks on hibernating mosquitoes in houses and barns by spraying and fumigation during winter months as well as during the summer and malarial months.

(3) Shaking out all coats and draperies, and systematic use of fly swatters against resting mosquitoes in corners and crevices of rooms daily.

(4) *Use of Mosquito Traps.*—In Panama and elsewhere labyrinth traps let into screens of windows of houses were useful to catch mosquitoes.

(5) Bats, lizards, and spiders are all natural enemies of the adult mosquito. The villagers in parts of Mexico deliberately introduce the mosquero, a special variety of spider, into their houses with the object of ridding them of mosquitoes and flies. The results are said to be "marvellously good."

(*b*) MEASURES AGAINST LARVÆ.—This involves attacks on all collections of water which may prove possible breeding-grounds. The measures are of great value, but have, of course, their limitations. They consist of the use of larvicides and drainage in all its forms—natural supplemented by artificial—followed by agriculture.

These measures—viz., use of larvicides, drainage, and agriculture—should be carried out wherever there is any collection of water which is a possible mosquito breeding-ground, and which cannot for any reason be filled in, canalized, or otherwise drained.

The following are the chief positions to be dealt with :

1. Marshes, rivers, streams, and all overflows of stagnant or semi-stagnant water.
2. Tanks, ponds, and pools.
3. Borrow pits.
4. Garden cisterns.
5. Disused wells.

6. Brick factories.
7. Grass farms.
8. All collections of stagnant or semi-stagnant water not included in the above. (See *infra* and p. 189.)

METHOD OF WORK.—Except for major engineering reclamation services, usually carried out by public works engineers, operations are best conducted by mosquito brigades.

The work of these brigades is applicable to towns, collections of villages, gaols, schools, plantations, and all large industrial works and factories. They should invariably be organized whenever large gangs of labourers are employed on famine relief works, railway construction, roads, canal works, tea-gardens, extensive building operations, etc.

Half a dozen coolies under one headman can be taught the duties in a few days, and a few gangs working efficiently can prevent much malaria amongst thousands of labourers.

A mosquito brigade consists of from ten, twenty, or more workers, under the direction of a skilled superintendent, the duties of the workers being:

1. To visit regularly once a week the compound of every house and drain, or fill up with earth every pool of water which can harbour mosquito larvæ, and maintain all minor drainage channels.
2. To add cresol to or cover with a layer of kerosene oil and crude petroleum every collection of water which is too large to be otherwise dealt with.
3. To remove all broken tins, pots, bottles, etc., which can contain water.
4. To instruct the inhabitants in the recognition of mosquito larvæ and in the methods of destroying them.
5. To see that by-laws requiring that all fixed receptacles of water, cesspools, etc., should be made *mosquito-proof* are carried out.

6. Spray or fumigate periodically native houses and cattle-sheds in the winter and summer.

7. Bring to the notice of the superintendent excavations made in building operations in the tropics and any householder in whose premises mosquito larvæ are frequently found.

8. During the rains to drain off quickly all superficial collections of water in existence for more than a week.

The superintendent should make careful observations of the seasonal prevalence of mosquitoes, their habits, and any improved methods which may be found to aid their extermination.

In towns which extend over a wide area it is necessary, of course, to employ a number of brigades, the town being subdivided into areas of such size that every house and every possible breeding-place of mosquitoes can be visited once a week by a member of the brigades. The whole of the brigade should be under expert European supervision.

Larvicides.—A larvicide is a chemical or other substance lethal to larvæ.

Chief varieties are:

(*a*) Chemical—(i.) Crude petroleum; (ii.) cresol; (iii.) Sanitas-Okol.

(*b*) Natural or biological—(i.) Fish; (ii.) frogs; (iii.) larvæ of dragon-flies, etc.

(*a*) CHEMICAL.—(i.) *Crude petroleum* is preferable as a larvicide to kerosene oil. Its colour aids the inspecting officer in seeing whether it has been properly applied or not. It is best used in two parts crude petroleum to one part of kerosene oil, and by means of an ordinary garden, or Mackenzie's, spray. In this way it can be squirted amongst grass and weeds, which otherwise break the continuity of the film and allow larvæ and pupæ to escape destruction. For gutters and ditches use drip cans discharging 20 drops per minute. Kerosene oil

being valuable for lighting purposes, natives are apt to misapply its use.

Three gallons of the mixture of crude petroleum and kerosene should be used for every 10,000 square yards.

Paris green also

(ii.) *Cresol.*—In Macedonia in 1915-1918 the British found cresol (1 in 80,000) preferable to petroleum as a larvicide. Its superiority is due to its forming an emulsion with the water, and thus not being affected by winds, and it is lethal to larvæ in doses non-poisonous to cattle. It also impedes or destroys the growth of algæ, the natural foodstuffs of the larvæ.

Mayne found cresol (1 part in 10,000,000) killed Culex larvæ within twelve hours under laboratory conditions. In practice all work was done with dilutions between 1 in 50,000 and 1 in 100,000.

Where cresol solution was used for brushing down canalized water-courses, stronger dilutions were employed, and enough cresol used to give a faint milky or opalescent tinge to the water, with, in my experience, eminently successful larvicide results.

In drinking water cresol in a strength of 1 in 20,000 (much stronger than was usually employed) was practically tasteless, and, of course, harmless to men and animals.

(iii.) *Sanitas-Okol.*—Where there is no danger of poisoning men and animals, Sanitas-Okol (1 in 10,000) may be used.

In the case of canals in which the flow is cut off periodically the larvicide should be applied after each flow of water.

(*b*) NATURAL OR BIOLOGICAL LARVICIDES.—The natural enemies of the mosquito larvæ are fish, frogs, dragonfly larvæ, and the larvæ of water-beetles.

(i.) *Fish.*—Small fish, such as "millions," have a reputation as destroyers of larvæ which they do not altogether deserve. Larvæ are frequently seen in the

same pools as millions, especially in side eddies shut off from the main current by weeds.

Fish will not eat mosquito larvæ if other food is available. Goldfish in artificial fountains are useful. Terni suggests that, when fish are used, such as have a food value plus larvicide action should be selected—*e.g.*, carp and tench.

(ii.) *Frogs.*—Tadpoles are said to destroy mosquito larvæ, but their frequent presence in the same pools belies this assertion.

(iii.) *Larvæ of Dragon-Flies and Water-Beetles.*—Dragon-fly larvæ have been largely used in the United States in antimalarial measures, and anyone has only to look for himself at a pool over which these flies are hovering to see how completely mosquito larvæ have been expelled from it. The larvæ of water-boatmen (Nectonideæ) also attack them, but not to any extent.

Drainage and Agriculture.—This applies especially to low-lying and marshy areas; and the drainage is in the first instance a Public Works service. Drainage should always be permanent rather than temporary, and only undertaken after careful geological and topographical survey of the area. It should be followed by agriculture conducted on lines suitable to the country and climate, both as a source of food to the community and animals, with the additional objective of increased industry, revenue, and prosperity. Better housing and living conditions are always productive of all-round improvement in general health and diminished prevalence of malaria.

The initial cost of permanent drainage is higher, but recurring cost of maintenance is minimized.

Subsoil drainage with field drains is preferable, but avoid raising the level of the subsoil water. The square area of drains should be as small as possible, and carefully graded under skilled engineer supervision. The

following are statistics of places where a considerable measure of success followed such work :

Place.	*Population.*	*Cost per Head.*	*Remarks.*
Ismailia ...	6,000 to 7,000	6.5 francs initial	Exclusive of quinine
Klang and Port Swettenham	4,000	£2 10s. initial	Exclusive of quinine
Panama ...	40,000	£10 annually	Inclusive of quinine and of sanitary expenditure

Expenditure of this nature may be possible over a limited area—*e.g.*, one or two marshes in the vicinity of an important residential centre, such as Port Swettenham, Mauritius, etc. ; but where a vast tract of territory has to be dealt with, as in India, China, Turkey, etc., it is often quite difficult, if not impossible, to obtain the money for a campaign of such magnitude. It is also noteworthy that it is now well recognized that mosquitoes will fly long distances, even up to ten miles.* Therefore, every district requires to be considered from various aspects, especially economic, financial, and possibility of future extension or prosperity of the community; briefly, will the work, if money is available, justify the initial outlay in money, in improved health and prosperity of the settlement? In carefully selected cases it undoubtedly will, and has done so—*e.g.*, Panama, Port Swettenham.

In malarious districts (1) rivers and streams, (2) ditches, (3) irrigation canals, (4) lakes, (5) marshes, and (6) natural and artificial collections of water of all kinds, must be regulated so as to prevent flooding, as most varieties of anophelines specially favour semi-stagnant water.

* *Major* R. E. Wright, "The Distance Mosquitoes will Fly," *Bombay Natural* History Society, xxv., No. 3, 1918.

The more important systems of dealing with large surface waters are as follows:

(1) RIVERS AND STREAMS.—The methods of preventing inundation of rivers are: (*a*) Vegetation on mountains and their slopes; (*b*) steps; (*c*) traverses and repellents: (*d*) settling basins and locks; (*e*) embankments; (*f*) works of defence against washing away of river-beds; (*g*) rough canalization—*i.e.*, means for avoiding overflows from storm water and formation of pools and eddies after subsidence.

(*a*) *Woods on Slopes of Mountains.*—These retain a certain proportion of the rainfall, and yield it to streams by slow degrees; deforested mountains at every heavy fall of rain permit of torrents descending from the slopes, which may cause excessive inundations of the plains. Efforts towards afforestation are therefore antimalarial.

(*b*) *Steps.*—When the slope of the mountains and hills is very precipitous, the construction of steps retards the fall of water after heavy rains, and is one of the few ways in which overflow of streams can be prevented.

(*c*) *Traverses, Repellents, and Dams.*—Traverses formed by trunks of trees and their branches, large stones, and similar forms of obstruction, have been used for centuries in the case of torrential streams and rivulets to check the force of the current.

(*d*) *Settling Basins and Locks.*—These operate by allowing the water to flow into reservoirs in such a way that overflow of the banks of the river is prevented.

(*e*) *Embankments.*—These are familiar means of preventing inundations of rivers, which should always be assisted by some form of canalization.

(*f*) *Paving.*—The paving of the bed of a river has been carried out in a few places successfully. In all cases the banks should be seen to, so that side-pools cannot arise. In the case of small streams, renovating the bed and banks so as to remove the possibility of pools forming is all that is necessary.

(*g*) *Rough Canalization.*—This process, which has a very wide application, consists in either (1) clearing the centre of streams, ditches, and canals so as to confine the water channel within two sides of limited surface, or (2) deepening the beds in order to remove *marginal* pools, and thus give a constant rapid flow of water. Such work should be commenced each year at the end of the rainy season, otherwise the canalization is destroyed by the rain-storm. The canals require repair after all heavy rain, in order to remove stagnant pools, which might breed mosquitoes. (N.B.—Avoid shallow, sheltered, side-eddies, and aim at narrow, deep, and rapid streams.)

(2) Ditches.—In natural localities the ditches should be embanked, deepened, and, if possible, paved, so as to be efficient as receptacles for storm water. Channels should be graded and **V**-shaped, contours being studied, and unnecessary ditches filled in. When there are a number of springs at the foot of hills, the outflow should be connected so as to form one large spring, in order to avoid the formation of small pools of clean water, which are specially prized by anophelines as breeding-places.

Anophelines breed especially in sluggish streamlets of rain water; in clean and clear terrestrial water, especially containing green algæ, weeds, and grass, which act as food to the larvæ; in hollows in rocks; and in ponds and cisterns. They are not found in rapid rivers and streams, or in water full of decayed vegetable matter, or very stagnant water.

(3) Irrigation Channels.—Whenever irrigation works, or any works which will increase the amount of water in the soil, are undertaken, it is necessary to simultaneously carry out adequate subsoil water drainage to remove the effluent. Neglect of this in the tropics is invariably associated with increased malarial endemicity in all newly irrigated districts.

One of the chief causes of the prevalence of fevers in *agricultural* villages and outskirts of towns where rice

is the main crop is that the surface soil of the village is kept more or less constantly moist, with the result that the existence of breeding-grounds for anophelines is universal. This could be obviated by proper arrangements for the reception and subsequent discharge of the irrigation water into prepared channels.

(4) LAKES.—Lakes surrounded by shallow pools should be deepened and banked, and the banks kept clear of grass, reeds, and weeds.

(5) MARSHES AND SWAMPS.—There are six antimalarial measures which may be undertaken with reference to marshes and swamps—viz. :

(*a*) The easiest method is that of cutting discharging canals, with a sufficient fall, into some watercourse or depression. The chief difficulties in connection with such canals are (i.) the removal of vegetation and (ii.) the prevention of silting.

In many marshes the setting free of collections of water by cuttings in the natural direction of the flow are often most useful.

(*b*) In the case of large marshes, intercepting or circumvallatory canals are cheaper and more effective than channels passing through or across them.

(*c*) The third method consists of covering the marsh with alluvium. A river is allowed to flow over malarious land during periods of flood, and there deposits a considerable amount of mud. By this means the area is gradually covered with a stratum of rich mould washed down from the higher land. This ingenious method has reclaimed malarious marshes in Italy, and might be applied to certain districts in the tropics.

(*d*) *Absorbing Wells.*—Where the underground stratum consists of gravel, pebbles, etc., which allow of percolation, the level of the underground water can be lowered considerably by sinking wells through the impermeable stratum.

(*e*) *Rubble Drains.*—Channels of requisite depth, cut

through or around a marsh and filled with stones, large at the bottom and smaller on top, are useful in lowering the subsoil water-level.

(*f*) *Drainage by Exhaustion.*—This measure has been successfully employed for marshes in Italy and America whose bottom is in some parts lower than sea-level. Ordinary discharging canals would be useless, as there is no fall for the water. The water is raised by special machines, and discharged into channels at a higher level, by which it is conducted to the sea.

(6) NATURAL OR ARTIFICIAL TANKS.—The small cisterns used for storing irrigation water in public and private gardens, when neglected, form veritable nurseries for mosquitoes, especially the Culex variety, but also anophelines. These cisterns should be cemented, or lined from edge to bottom with large stones, and furnished with covers. Fish, water-boatmen, and other aquatic forms of life are useful in keeping down the breeding of larvæ in tanks and artificial fountains.

In the construction of railway lines engineers should pay special attention to the natural drainage of the subsoil and the sides of the permanent way, particularly in the vicinity of villages and stations, as a rise in the level of the subsoil water results in marsh patches, offering breeding facilities for anophelines.

Neglect of this principle has been the cause of many malarial outbreaks associated with the building of railways in the tropics.

3. **Quinine Prophylaxis.**—Quinine prophylaxis consists in the administration of the drug to the non-infected, as contrasted with its use to prevent and minimize attacks in an already infected individual.

Many authorities on tropical medicine are still undecided (1) as to the value of quinine as a true preventive of infection by the malarial parasite, and (2) as to the amount of dosage necessary to effect protection against the disease. It can never replace the positive

methods of personal protection and mosquito destruction. The general consensus of recent opinion as to its use under war conditions in a bad malarial zone, 1915-1918, is that it had little or no effect, and was not worth the expense, and that more effect could have been obtained by concentrating energy on measures of "personal protection." It is not claimed that it did not protect a few individuals, but the incidence of malaria was so enormous that it could hardly have been higher without the issue of so-called "prophylactic quinine." Under normal peace conditions, where personal protection and mosquito destruction can be more complete, and the degrees of infection by bites can be reduced to a minimum or within the control of, say, 10 to 15 grains daily, prophylactic quinine may be of great value, especially for short periods of tropical residence, such as a shooting trip, or unavoidable exposure on night journeys by train or river-boat through a malarial zone. This measure should never justify lack of precautions as to personal protection and mosquito destruction.

It is also to be remembered that if the drug is given over a prolonged period, there is a tendency to producing immunity to the curative effect of quinine if the individual later contracts malaria (Still).

Quinine tends to prevent relapses in already infected men, but relapses are best prevented by early and active treatment during the malarial attack, thorough treatment for some time after it, and by keeping the natural resisting factor normal.

Method of Quinine Prophylaxis.—Innumerable methods have been tried by Celli, Koch, Bertrand, Balfour, and others—viz., 6 grains daily, 10 grains daily, 20 or even 30 grains daily. None of these in the war of 1915-1918 gave diminished incidence, but under normal tropical conditions, as indicated above, a dose of 10 grains (or 15 grains in bad districts) of quinine once daily *in the evening* an hour before dusk may protect

for a limited period. It is best administered as an orange-flavoured solution. The object of giving it in the evening is that the greatest concentration of quinine may be in the blood at night—*i.e.*, when most likely to be bitten by infected mosquitoes. Quinine quickly enters the circulation when taken by the mouth, and is eliminated in the course of a few hours.

Tanret's or Mayer's reaction is very largely employed to test the urine of patients under treatment with quinine to see that they are actually taking it.

It consists of mercuric chloride 13·546 grammes, and potassium iodide 49·8 grammes, in distilled water 1 litre. This reagent gives a precipitate in the presence of quinine or other alkaloids in the urine.

Quinine disinfection is the name given by Koch to administration of quinine to the infected, particularly natives and other chronic malarial carriers. He gave 15 grains on two or three successive days of each week, the course to be continued for three months. This method was adopted on a large scale in German East Africa with good results, and has been carried with great success in Macedonia, Turkey, and other places in recent years.

4. **Good House Sanitation in Urban and Rural Districts.**—Tropical residents should see personally that larvæ have no chance to breed in their environment, and should also attempt to destroy adult mosquitoes which lurk in corners, rafters, and curtains or hangings of their room, stables, and outhouses in the season, and from one season to another, by fumigating their rooms with sulphur (1 pound to 1,000 cubic feet) or less expensive materials, such as Indian *gobar* (cow-dung cakes) or bazaar incense, or by spraying them with formalin or other insecticides, such as petroleum emulsion. Thick curtains of all kinds should be removed from the living-rooms in hot weather, as they form favourite lurking grounds for mosquitoes. Clothes hung

on pegs should be shaken out and placed in the sun at least once a week.

Large tubs containing palms and shrubs should not be kept near bungalows, as they often contain larvæ, and shelter adult female mosquitoes by day from the sun. All rooms, including bathrooms, should be well lighted and airy, and accumulations of water in sullage-water catchpits should not be tolerated.

These points are of special importance against varieties of culicine mosquitoes (*Culex fatigans* and *Stegomyia fasciata*, the vehicles of dengue and yellow fever respectively). Kitchens and servants' quarters and stables require special attention for infected or hibernating anophelines.

Servants persist in keeping tubs, jars, and tins full of drinking or sullage water, or manufacture pools by throwing dirty water on the ground from the kitchens or their own "go-downs."

They have a special predilection for storing jam tins, sardine tins, bottles, and other rubbish behind the kitchen and out-offices. Unless these and their surroundings are regularly inspected by the occupant of a bungalow, and everything of this kind cleared away, plenty of places for mosquitoes to breed will arise. The same remarks apply to servants' latrines, which are particularly attractive to some species of mosquitoes; indeed, at Ismailia it was found that the great majority of mosquitoes came from tanks in which excreta were received.

The occupants of a house in a tropical town or village should be held responsible for keeping their bungalows as far as possible free from mosquito-breeding conditions. It is obvious that no attempts at general sanitation in the way of drainage will be of use if good domestic sanitation is not insisted on.

Far more powerful foes of malaria than physical agencies or quinine are a good water-supply, good drain-

age, good paving, good conservancy, good building organization, and an organized hygienic service to carry out and maintain systematically the necessary sanitary routine.

The chief allies of malaria in the tropics are neglect of ordinary sanitary precautions, and especially puddles and pools in and around buildings, and empty vessels containing water in which the mosquitoes breed ; and last, but chiefly, non-use of mosquito nets.

Malaria disappears before modern and civilized hygiene, as we know from English experience, and even from our knowledge of some districts in the tropics.

The Epidemiology of Malaria.

The health officer in the tropics is frequently called upon to make a malarial survey before any measures of prevention are adopted.

The procedure to be adopted consists of :

1. Ascertaining the prevalence of malaria by a spleen census.

2. Determining the endemic index.

3. Ascertaining anopheline varieties in the locality and their facilities for breeding.

4. The sporozoite rate.

5. The prevalence of European malaria and relative admission rate to hospitals by numbers.

6. Meteorological and climatic features of the district (for ten years if possible).

1 and 2. **Spleen Census and Endemic Index.**—These may be taken together at :

(*a*) Beginning of malaria season.

(*b*) End of malaria season. The mean between the two figures obtained is what is required.

Avoid a mixed adult and a child count. Examine only children between two and twelve. Get influential *native to* collect children. Bribe with pence, and collect *blood-films* and examine spleens at same time. Ex-

amine blood-films, noting (1) number showing parasites, (2) number showing pigmented leucocytes, (3) number showing large mononuclear increase.

3. **Facilities for Anophelines and their Species Breeding.**—Collect adults and larvæ, and determine species.* Make spot map, noting breeding-ground and species found. Make test pool in sheltered place.

4. **Sporozoite Rate.**—Collect as large a number of female anophelines as possible, and dissect them for species, identification, and varieties of malarial parasite.

5. **European Incidence.**—In addition to the foregoing, examine blood of as many Europeans as possible, noting as above. Make map showing relation of native dwellings to bungalows. Note admission rate to local hospitals for period of years.

With these data the health officer will be able authoritatively to advise his local authority.

Summary and Conclusions re the Prevention of Malaria.

The measures advocated are :

1. Protection of the individual (infected and non-infected) in its widest application, including thorough treatment of infected, and as a war measure removal of the grossly infected from the endemic zone.

2. Destruction of anophelines—*i.e.*, adult larvæ—and their breeding and hibernating grounds.

3. Quinine prophylaxis.

Nos. 1 and 2 are both of the greatest importance in peace or war. Quinine, though of little use as a prophylactic under war conditions, should supplement, but not replace, personal protection and mosquito destruction during periods of unavoidable exposure to mosquito bites on journeys, short shooting expeditions, and brief residences in a malarial zone.

* In searching for larvæ in streams or puddles it is important to stir up the *water well*, as larvæ and nymphæ can be seen better in *muddy water*.

The money expended on prophylactic quinine in Macedonia would have supplied thousands of mosquito-proof huts and unlimited mosquito nets and gauze (Wenyon).

"Perhaps we must make allowance for the frailty of man as well as for the wiliness of the mosquito, but whether this is true or not, practical experience is to the effect that it is usually best to concentrate all available effort on one carefully selected method, which can then be brought to a high degree of perfection" (James, "Malaria at Home and Abroad," p. 199).

For an expedition to a malarial country the following should be provided:

1. Mosquito nets of two types:

(*a*) Hospital pattern nets of the usual rectangular shape.

(*b*) Bivouac type, one for each individual, with material to keep in repair. All netting to be eighteen meshes to linear inch; but if Phlebotomus is known to occur, the mesh should be smaller—twenty-two meshes to the linear inch.

2. Mosquito-proof huts for dining and living, made of wood, canvas, and copper gauze.

3. Mosquito boots.

4. Mosquito veils and gloves.

5. Turn-down shorts.

6. Mosquito repellents—*i.e.*, aromatic oils. Best employed with a vaseline or lanoline vehicle.

7. Swatters, sprayers, and fumigators.

8. Pamphlets as propaganda.

9. Experts to report on the district (Wenyon) and suggest measures of prevention.

Finally, it should be noted that Bentley has recently observed that with improvements in agricultural methods and utilization of marshy lands, malaria tends to disappear as much from physical improvement, and thereby greater resistance of the people, as from the destruction of mosquitoes by drainage. The resulting greater prosperity makes better food and housing obtainable.

CHAPTER XII

DISINFECTANTS AND DISINFECTION IN THE TROPICS

THE object of disinfection is, of course, to destroy the germs of disease, but, unfortunately, three classes of agents are usually grouped together under those simple headings—viz :

1. Antiseptics—*i.e.*, substances which arrest the action of bacteria, but do not destroy them, such as boracic acid.

2. Deodorants—*i.e.*, substances which destroy or mask disagreeable odours; for example, charcoal, toilet vinegar.

3. Disinfectants proper or bactericides—*i.e.*, substances which really destroy germs, such as carbolic acid.

1. **Antiseptics.**—An antiseptic is an agent which arrests or impedes the growth of microbes. The application of this group is limited to substances and places where removal or destruction are undesirable. Its members require the most careful and discriminate employment to be of value in preventing the evil results of infection by pathogenic organisms.

Preservatives are closely allied to antiseptics in their effect upon organic substances, and are really antiseptic processes.

The following are the main food preservatives:

PHYSICAL MEANS.—(*a*) Cold—*e.g.*, freezing, or chilling (*i.e.*, keeping temperature just above freezing).

(*b*) Exclusion of air—*e.g.*, coating with paraffin or fat, or dipping into boiling water ; also water-glass coating to eggs. Hermetically sealing in tin cases or other vessels.

(*c*) Drying or smoking.

(2) Chemical Means.—(*a*) Injection of preservative solutions.

(*b*) Salting or pickling.

2. **Deodorants.**—Decomposition and putrefaction are the result of micro-organic life in the resolution of organic substances into their innocuous elements. During this transformation malodorous gases are given off, and deodorants act by overpowering, absorbing, or breaking up these gases. They produce little or no effect upon the decomposing substances, and are of little practical utility to the health officer, as the cause of the odour should be removed and not disguised.

3. **Disinfectants Proper.**—Disinfection, in the more restricted and accurate sense, implies the destruction of the infection produced by the specific micro-organisms of disease.

In all the recognized infectious diseases, whether the specific organisms have been discovered or not, disinfection is applied to the destruction of the specific infection, and the degree to which this destruction is effectually accomplished can be accurately measured.

Action of Disinfectants.—(1) By direct bactericidal action through *physical* means—*e.g.*, heat, dry or moist.

(2) By direct *chemical* bactericidal action and coagulating the protoplasm of bacteria—*e.g.*, perchloride of mercury, phenol.

(3) By *oxidation*—*e.g.*, bleaching powder. In the presence of moisture and CO_2 or other acids, hypochlorous acid ($HClO$) is liberated, and this acts as an oxidizing agent by splitting up into HCl and O.

(4) By *Brownian* movement. In emulsions the particles are in a constant state of Brownian movement, and thus a kind of bombardment of the organisms is kept up by the incessant movements of the disinfectant molecules. The activity of the following are probably due to this form of action: Izal, cresol, lysol, Kerol, Jeyes' Fluid. In the presence of organic matter, Brownian

movement of the particles of emulsion is impeded, and therefore the germicidal action of the emulsified disinfectant is not nearly so great as when it acts on the naked organism.

CONDITIONS ESSENTIAL TO DISINFECTION.—(1) Germicidal power.

(2) Sufficient strength or intensity.

(3) Maintenance for a sufficient time.

(4) Sufficient contact or exposure.

True disinfectants may be classed under the following headings:

(1) Natural disinfectants.
(2) Physical disinfectants.
(3) Chemical disinfectants.

(1) NATURAL DISINFECTANTS.—Fresh air and direct sunlight (ultra-violet rays of white light) will kill most bacteria, whilst living micro-organisms are sooner or later attenuated in their disease-producing activities, and finally killed by drying.

Thus, the *Spirillum cholera*, when dried, dies in from three hours to two days (Koch).

B. typhosus is destroyed in from half an hour to two hours by direct solar rays, and in five hours by diffuse daylight. The diphtheria bacillus is destroyed by half an hour to an hour's exposure to direct sunlight; whilst Koch found that the tubercle bacillus is killed by the rays of the sun in from a few minutes to several hours, according to the thickness of the mass exposed.

As no micro-organisms develop in the dry state, the influence of drying on their multiplication is of manifest importance, and this fact makes it clear that the maintenance of the tropical habitation and its surroundings in as dry a state as possible is a stringent sanitary necessity. The frequent airing of bedding and clothing secures the desired dryness, and, in addition, the oxygen of the air exercises a destructive effect on such organisms as may be harboured in these articles; whilst the

agitation to which they are subjected in a strong breeze not only mechanically dislodges and removes a considerable proportion of the adherent microbes, but also markedly interferes with the development of certain species. There is considerable difference in resistance to desiccation. Tuberculosis and diphtheria can endure desiccation for weeks, whilst plague, cholera, and typhoid fever are killed in a few hours.

Nature's disinfectants are, therefore, fresh air, winds, and sunshine.

(2) PHYSICAL DISINFECTANTS.—The physical disinfectants consist of heat in its various forms.

Heat is the simplest and most thorough disinfectant.

Varieties:

(*a*) Fire or burning.
(*b*) Hot air or dry heat.
(*c*) Boiling } Moist heat.
(*d*) Steam }

(*a*) *Fire.*—Destruction by fire is the most thorough means of disinfection, and it should always be employed for articles of little value. When possible, the material should be soaked in kerosene oil to ensure complete and ready combustion.

Bazaar dwellings, which are cheap and readily reconstructed, are best disinfected by fire, especially in such diseases as plague. Whenever such action is taken for portable articles, the employment of a closed incinerator is desirable, for if destruction by fire is carried out in the open air, small unburnt particles carrying infectious material may be scattered by the action of the wind. Huts with mud walls and earthen floors can be cleared of fleas by spreading straw to a depth not exceeding 6 inches and then igniting it. The resulting flame does not exceed 2 feet in height, and effectively destroys all fleas.

(*b*) *Hot Air.*—This method of disinfection came to the front during the war, as it is an efficient and rapid

infestor of lice and their "nits," which are killed in five minutes by exposure to a temperature of 55° C. (Bacot).

The advantages of hot air for disinfestation are: (1) It is economical of fuel; (2) it can be employed in an ordinary oven, a pit, or rough hut in emergencies; and (3) within certain limits it does not destroy articles such as furs, leather, india-rubber, and bound books.

Its disadvantages for disinfection are: (1) It has slow and feeble penetrating powers for bulky articles such as beds, pillows; (2) it is likely to stain certain articles; and (3) it renders some articles brittle, and damages others —*e.g.*, ground-sheets and mackintoshes. Dyes are little affected by either hot air or steam.

(*c*) *Boiling.*—One of the best methods of disinfection is boiling. There are few organisms, other than those bearing tetanus anthrax, which will stand boiling for a few minutes, and still fewer which will stand subsequent washing in soap and water. It is specially useful for linen, towels, sputum pots, and drinking utensils.

The disadvantage of boiling is that it is apt to fix albuminous stains; and if it be employed, *e.g.*, for clothes, these must be first soaked in cold water and washed with soap and soda. The water in which they have been soaked and washed must also be disinfected by boiling.

In boiling instruments for sterilization 1 per cent. bicarbonate of soda should be added to prevent rusting.

(*d*) *Steam.*—Applied in special forms of apparatus, steam is now largely utilized in the tropics for disinfection of bedding and clothing. Its superiority over hot air is due to the following reasons:

(i.) The large amount of latent heat in steam. Steam in contact with an article to be disinfected, which is at a lower temperature than the steam, undergoes condensation, and in the process parts with its latent heat, thus increasing the temperature of the article. When steam condenses into water, it parts with latent heat to the amount of 893·7 units for every pound of water which was originally converted into steam. Hot dry

air, on the other hand, has no latent heat, but, on the contrary, has its temperature reduced owing to the fact that, before the temperature of the article can be sufficiently raised, any moisture it contains must be evaporated, and the process of evaporation uses up a certain quantity of heat.

(ii.) The high penetrative power of steam. The condensation of steam is accompanied by diminution in volume, and the creation of a partial vacuum in the interstices of the articles being disinfected. To fill the vacuum more steam presses forward, and in its turn undergoes a similar process, until every part of the article is penetrated.

Pressure increases penetrative power. The penetration of hot dry air, on the contrary, depends on conduction slightly aided by convection, and dry air is a slow conductor. Moreover, the diminution in volume of hot dry air on being cooled is trifling compared with that produced in the condensation of steam.

(iii.) A lower temperature continued for a shorter time suffices for adequate disinfection.

(iv.) The risk of fire is slight. Fabrics and material, with the exception of paper, leather, fur, sealing-wax and resin, glue, feathers, and rubber, are not likely to be injured.

The various types of apparatus used for disinfecting by steam have been classified as follows:

(i.) *Low-Pressure Steam Disinfectors.*—Apparatus in which steam at low pressure, such as 2, 3, or 5 pounds per square inch, is relied on. The highest temperature which can be reached by these stoves is 110° C. This is generally sufficient for all practical purposes, and these disinfectors are cheaper than high-pressure varieties.

Examples: Reck and Thresh.

(ii.) *High-Pressure Steam Disinfectors.*—Apparatus in which steam at high pressure, such as 10 pounds and over, is employed. A temperature of 115° to 120° C. can be obtained in these stoves, and an exposure of articles from a quarter to half an hour suffices for their

disinfection. The higher the pressure of the steam, the more rapid the penetration, and the less the time required for disinfection.

Examples: Jessop, Bowman, Washington Lyon, and Equifex.

The health officer must have clear notions on saturated and superheated steam.

(i.) Saturated steam is steam at the temperature at which it condenses, and the temperature of the condensation point rises as pressure increases.

(ii.) Superheated steam is steam at a temperature higher than that at which it can condense; therefore superheated steam has to be cooled down into the state of saturated steam before condensation ensues. If superheated steam is used for disinfection it loses heat by conduction, and the rise in temperature of the articles treated approximately corresponds to the fall in the temperature of the steam. With saturated steam, on the other hand, immediately it is cooled an enormous amount of latent heat is set free by the change in state from the gaseous to the liquid condition; therefore saturated steam is a far more efficient disinfectant than superheated steam. These considerations should always influence the health officer in his choice of a steam disinfecting apparatus.

There are several varieties of disinfecting apparatus in common use in the tropics. Space will only permit of the description of three—viz.:

(*a*) The Washington Lyon.

(*b*) The Equifex or Velox.

(*c*) The Thresh; and

(*d*) A type of improvised disinfector—viz., the Serbian barrel.

(*a*) *The Washington Lyon Apparatus.*—This apparatus is oval in section, and is usually worked with a pressure of 10 to 20 pounds per square inch in the jacket, and 5 to 10 pounds in the chamber, so that the steam in the latter is superheated, a precaution against condensation.

The articles having been introduced and the doors closed and secured, steam is first directed into the jacket, so as to heat the contents of the chamber. Steam is next admitted into the chamber itself, and soon reaches the full pressure required. It is found that penetration is more rapid if the pressure is intermitted once or twice. This is readily effected by turning a cock. Ten to twenty minutes suffice for the penetration of even bulky articles, and at the end of that time the steam is allowed to escape from the chamber, the door is opened, and the articles dried by exposing them to the heat from the jacket for a few minutes.

(*b*) *The Equifex.*—This type is worked with a saturated, not superheated, steam at 239° F., with 10 pounds pressure. The chamber consists of a steel cylinder made without a steam-jacket (Geneste), so as to avoid the risk of superheating. The cylinder is packed with non-conducting composition, and covered with wood, so as to reduce loss of heat by radiation. Separate doors for infected and disinfected articles are provided. Velox is similar to the Equifex.

(*c*) *The Thresh Apparatus.*—In this form of apparatus current steam at a temperature of 225° F., and not under pressure, is used. The steam at this temperature is obtained by using a saline solution, which boils at a higher temperature than water.

The process is continued for about forty-five minutes, and at the end of that time a current of previously heated air is drawn through the chamber to dry the disinfected articles.

The apparatus is simple, efficient, and cheap.

(*d*) *Serbian Barrel Disinfector.*—A large central opening with five or six holes around it is made in the bottom of a large barrel. Steam enters these holes from a circular boiler erected underneath the barrel. The boiler should have a surface area equal to the base of the barrel. To prevent any escape of the steam, a narrow sausage ring, filled with sand, is placed between the boiler and the

barrel. To keep the clothes away from the holes in the bottom, a small frame made of two or three crossed bars of thin wood is placed inside the barrel about 9 inches above the holes. A heavy wooden lid is provided to retard the escape of steam. The one essential for success is that steam must be generated rapidly enough to fill the barrel in 40 seconds. This necessitates a vigorous fire. The time required for disinfestation of clothing is one hour.

All good disinfector models open at both ends to permit articles being introduced one side and removed at the other.

The drying process in machines is not necessary on dry days, as one rapid shake of each article will dry it. In inspecting current steam disinfectors the health officer should note whether there is a continuous current of steam from the outlet pipe.

(3) CHEMICAL DISINFECTANTS.—The number of chemical disinfectants on the market is enormous. They may be divided into :

(*a*) Gaseous.
(*b*) Liquid.
(*c*) Solid.

(*a*) *Gaseous Disinfectants.*—The principal gaseous disinfectants are burning sulphur, formaldehyde, chlorine, and hydrocyanic acid gas.

Burning Sulphur.—The gas produced by burning sulphur has been in use for centuries as the most convenient form of gaseous disinfectant. It is essential that all surfaces with which gas is to come into contact should be thoroughly damped, as the gas only acts in the presence of moisture.

Rolled sulphur or the specially prepared candles should be used, as powdered sulphur is frequently impure. Three pounds of sulphur are required for each 1,000 cubic feet of space.

For destroying rats and ‘ hipboard a Clayton *apparatus* is useful. It urous acid gas

under pressure ; 3 pounds of sulphur per 1,000 cubic feet is the usual allowance. A simple and rapid calculation is to allow 3 pounds for each 10 tons of gross tonnage. The fumigation is continued for twelve hours.

Formaldehyde.—This gas, liberated from tablets by heating in some special form of lamp or Trillat's autoclave, has largely replaced sulphur of recent years (twenty-six tablets are used per 1,000 cubic feet).

The Lingner apparatus, in which glyco-formal is vaporized and ejected, has been used with success in Western India.

Formaldehyde may also be readily generated by pouring formalin on permanganate of potash.

The proportion of the two substances which gives the best results and the driest residue is 2 parts of formalin to 1 part of permanganate. The method is very effective, simple, and rapid by virtue of the inexpensive apparatus required, and is preferable to the older and more cumbersome methods. It acts best if the air is dry, and is harmless to most colours and most surfaces, except iron.

One pint of formalin poured on 10 ounces of permanganate in ordinary 3-gallon galvanized iron pails is sufficient to efficiently disinfect 2,000 cubic feet. The period of disinfection should be six hours. From 60° to 70° F. is a proper temperature, and the air of a room must be rendered moist in a dry country.

As soon as the last portion of the reagents has been mixed the operator must leave the room and seal up the door.

Use not more than ½ pint formalin to 5 ounces permanganate owing to frothing.

The room must be kept closed for twenty-four hours.

On entering the room after this period the nose, mouth, and eyes should be covered with a damp cloth. The remaining formalin vapour may be dispersed by *sprinkling* a few drops of ammonia around the room.

Chlorine.—This element is useful as a disinfectant, but is a powerful bleaching agent, and should only be used where the other two gases are not available.

Use 2 pounds of bleaching powder and about one pound of the commercial acid for every 1,000 cubic feet of room space. If strong sulphuric acid is used about one-third of the quantity of acid will suffice.

Hydrocyanic Acid Gas (see also p. 156).—Generated by the addition of commercial sulphuric acid to potassium or sodium cyanide. Much used in South America and the Middle East against bugs and insect pests, especially in detached houses, railway carriages, and for ships' holds. Rapid and effective, but, owing to its extremely poisonous nature, should only be used under experienced supervision.

Hydrocyanic acid gas is best generated by the following method : Place the required quantity of commercial cyanide in a muslin bag suspended from a string in the centre of the room or compartment to be disinfected. Pour the acid into a large basin containing water. Seal up all openings to the room except the door, and place the acid and water in the centre of the room or compartment below the suspended bag of cyanide. From the door the operator gently drops the bag of cyanide by means of the string into the basin, rapidly goes out, and seals up the door. One ounce of commercial cyanide, 1½ ounces of strong sulphuric acid, and 3 ounces of water should be used for each 100 cubic feet of space. The room should be kept sealed up for four or five hours.

It should be borne in mind that the *air* of an infected room can readily change, and therefore does not require disinfection. Moreover, micro-organisms have weight, and do not remain in the air, but sink on the floors, walls, furniture, so our attention should be devoted to surface disinfection.

(*b*) *Liquid Disinfectants.*—A good liquid disinfectant should possess five characters:

(i.) It should be directly germicidal within reasonable time.

(ii.) It should be adapted for domestic use.

(iii.) It should be soluble in, or capable of emulsion with, water.

(iv.) It should not possess injurious effects on human tissue.

(v.) It should not be too costly.

The following are some of the chief liquid disinfectants: (1) Cresol, (2) lysol, (3) carbolic acid, (4) chinosol (5) solution of perchloride of mercury.

Attempts have been made to standardize the disinfectant power of chemical disinfectants in multiples of pure phenol solution under similar conditions. This constitutes their carbolic coefficient—*i.e.*, their germicidal power compared with phenol as unity.

Exact standardization is of course impossible, owing to the variability of the protoplasm and resistant power of micro-organisms, or even different strains of the same species, and laboratory conditions are only rough indicators of their practical value.

Five methods are referred to in "Aids to Tropical Medicine," section xii. We will only refer to two:

(i.) The Rideal-Walker.
(ii.) The Martin-Chick.

(i.) *Rideal-Walker.*—To 5 c.c. of the disinfectant in various dilutions are added 5 drops of a twenty-four hours' subculture of the organism in broth. Mix, and then subculture every two and a half minutes up to fifteen minutes, and incubate for twenty-four hours at 37° C. The germicidal potency is expressed in multiples of a solution of phenol doing the same work in the same time with a twenty-four hours' broth culture of the typhoid bacillus.

The suggestion has been made to alter the Rideal-Walker coefficient method of examining disinfectants by introducing organic matter—milk, urine, fæces, etc. —into the disinfectants, as it is claimed that the real test of a disinfectant is the strength and time of exposure which will enable it to kill organisms in the presence of such, but the idea has met with disfavour.

(ii.) *Martin-Chick*.—Three per cent. emulsion of human excreta dried at 216° F. and sterilized, and added to the test organism with the disinfectant to be tested, allowing an interval of fifteen minutes, and subculturing. The coefficients obtained are less than in (i.) (Whitelegge).

(i.) Cresol, cyllin, lysol, and many of the aromatic series of compounds (*e.g.*, Izal, Jeyes' Fluid) form emulsions with water, and, as generally used, are ten to twelve times as strong as carbolic acid.

Cresol is generally used in a strength of 2½ ounces to 1 gallon. It does not make a satisfactory emulsion with sea water.

Lysol is also extensively used as a disinfectant in midwifery.

(ii.) *Carbolic Acid*.—Five per cent. is useful for surgical purposes, but for general disinfecting purposes it is seldom used. It is also, of course, highly poisonous.

(iii.) *Perchloride of Mercury*.—Useful for surgical work. It is poisonous, corrodes metals, coagulates albumen, and cannot penetrate substances so coated. Its practical value for disinfection purposes is in consequence seriously diminished.

(iv.) *Chinosol*.—One in 1,000 is a good disinfectant.

(v.) Potassium permanganate in 5 per cent. solution is a true disinfectant, but it is expensive. Its chief uses in the tropics are (*a*) as a toxin-destroying agent in cholera, and (*b*) as an application in snake and scorpion bites. It is used to "pink" wells during cholera epidemics in India (see Chapter III., Water, p. 49).

(c) *Solid Disinfectants.*—

(i.) Lime.
(ii.) Bleaching powder.
(iii.) Soap.

(i.) *Lime.*—Freshly burnt lime is a cheap and useful germicide. It must be used fresh, for if stored for any length of time it is converted by the action of the air into calcium carbonate, which has no germicidal properties. Mixed with 4 parts of water it is a useful disinfectant of excreta and grossly infected material bulk for bulk. As "whitewash" it is stated by some authorities to destroy all germs, except those of anthrax and tuberculosis. Prior to the application of whitewash the surface should be well scraped to remove bacterial life, rather than bury it under a layer of even germicidal limewash.

(ii.) *Bleaching Powder.* — Bleaching powder is a powerful disinfectant when fresh. It consists of lime saturated with chlorine, and, according to the British Pharmacopœia, should contain at least 30 per cent. free chlorine. It is very useful when fresh as a water sterilizer, and for surgical purposes in the form of eusol. Eusol, if not made with reliable bleaching powder, may be worse than useless as a germ deterrent.

Eupad is the name given to a powder consisting of equal weights of finely ground bleaching powder and powdered boric acid well mixed. It ought to be kept in well-stoppered bottles and not exposed to light; it is not toxic, and is harmless to tissues.

Eusol is a solution of free hypochlorous acid prepared by treating Eupad with water.

It is prepared as follows: 25 grammes of Eupad are shaken with 1 litre of water, allowed to stand for a few hours, then filtered through cloth or filter-paper.

Chloride of lime was formerly largely misused to

disguise offensive odours from drains, etc., instead of ascertaining and removing the cause of the odour.

(iii.) *Soap.*—Common soap is one of the most generally useful of the chemical disinfectants. A mixture of soap and cresol (saponified cresol) is very largely used for disinfecting purposes in the British Army.

It is worth remembering that in the manufacture of soap it is boiled; therefore, when the surface layer of a piece of soap is removed the remainder is actually sterile.

Ordinary household soap through its alkali not only destroys germs, but also tends to dissolve the outer covering of their spores. It also washes away the greasy materials which frequently protect bacteria from the action of the natural disinfectants—sunlight and oxygen—and is therefore a very valuable purifier.

In taking measures of disinfection, the advice of Rosenau is noteworthy: "Man is the fountain-head of the infections to which he is heir; hence the most effective place to apply disinfectants is at the bedside and to the excretions, especially those from the nose, mouth, and bowels."

When a case of infectious disease occurs, the following rules should be observed:

(i.) In certain diseases complete disinfection of the sick-room, bedding, and clothing is necessary—viz., cholera, mumps, whooping-cough, diphtheria, scarlet fever, smallpox, plague, anthrax, yellow fever, typhus fever, puerperal septicæmia, tuberculosis and relapsing fever, poliomyelitis, and encephalitis lethargica.

(ii.) In the following only the patient's immediate surroundings—*i.e.*, 6 feet all round the bedside, and not the whole room—need be disinfected—viz., dysentery, enteric fever, croup, measles, chicken-pox, pneumonia, erysipelas, rubella, Mediterranean fever.

A. **Disinfection of Bedding, Clothing, etc.**—1. Whenever a steam disinfector is available, all articles of *bedding, carpets,* hangings, etc., which are not likely

to be injured by steam should be sent to the disinfecting station.

2. When a steam disinfector is not available, cotton and linen articles should be boiled for half an hour. Blankets and other woollen articles and coir fibre should be soaked for half an hour in $2\frac{1}{2}$ per cent. saponified cresol (4 ounces to 1 gallon). Cloth articles can be sprayed with a 5 per cent. solution of pure carbolic acid in water, and exposed to the sun for three or four days. Leather and other articles should be sponged or sprayed with 5 per cent. formaldehyde solution (8 ounces to 1 gallon).

B. **Feeding and Cooking Utensils, and Spitcups, Bedpans, and Urinals.**—Boil for fifteen minutes as a general rule, but immersion in a 20 per cent. hot solution of washing soda suffices for most infectious diseases. It will not, however, serve in cases of infection by the tubercle bacillus. Table knives, mounted forks, and similar articles should be soaked for two hours in 5 per cent. formalin solution.

C. **Grossly Infected Material**, excreta, etc., should be disinfected by boiling or mixing with strong disinfectant, such as quicklime in water (1 in 4) or an equal bulk of strong cresol solution, all excrement being thoroughly broken up and exposed to the action of the disinfectant for at least half an hour before disposal.

D. **Room Disinfection.**—1. Formaldehyde solution is the most suitable. But when there are hangings, curtains, etc., use either formaldehyde gas or sulphur. (N.B.—Sulphur tarnishes metals and gilt frames.)

Formaldehyde solution for spraying surfaces is used the following proportions :

Formalin	8 ounces.
Glycerine*	5 per cent.
Water	to 1 gallon.

Mackenzie's sprayer is the most suitable pattern to e in spraying for disinfecting purposes.

* *Confers* viscosity and delays drying of the spray on walls.

Use 1 gallon for every 400 square feet of surface to be disinfected.

2. *Formaldehyde Gas.*—(1) Paraform tablets, 26 to 1,000 cubic feet, or (2) formalin and pot. permanganate (½ pint to 5 ounces per 1,000 cubic feet). Use a 3-gallon galvanized iron pail for each ½ pint, owing to frothing. Effective, simple, rapid. Length of exposure for disinfection, six hours.

3. *Sulphur Dioxide Gas.*—8 ounces of methylated spirits to each 1½ pounds of sulphur.

(1) The walls of the room occupied by the patient should be scraped and relimewashed.

(2) Furniture, floors, and woodwork should be scrubbed with hot water and soap, or saponified cresol.

(3) Earthen floors should be saturated with a disinfectant preparation, preferably kerosene emulsion with 2 per cent. of cyanide of mercury.

(4) The woodwork of the latrine used by the patient should be scrubbed periodically with saponified cresol (1½ ounces to the gallon), and the floor saturated with the same solution.

E. **Vehicles.**—Spray with formalin solution or wash down with cresol solution (1½ ounces to the gallon).

F. **Schools.**—1. Treat walls and ceilings above dado with limewash.

2. All dadoes, woodwork, desks, wash with cresol solution.

3. Ceilings relimewash.

Destruction of Insects.

Good disinfectants are not necessarily good insecticides, as, for example, mercuric chloride, which, although it is one of the most powerful of all disinfectants, has little influence on insect life.

Laboratory experiments have shown that fleas will emerge unscathed from an exposure of ten minutes in an acid solution of corrosive sublimate of such powerful strength as 1 in 500. Moreover, the disinfecting

action of this chemical is considerably neutralized by organic matter on floors and walls, and especially in the case of mud floors of native huts and houses which are smeared with cow-dung.

The best insecticides are divided into two groups—*i.e.*, chemical and physical.

1. **Chemical.**—
   (1) Pesterine, or crude petroleum.
   (2) Kerosene oil emulsion.
   (3) Petrol.
   (4) Saponified cresol.
   (5) Sulphur dioxide gas.
   (6) Formaldehyde.
   (7) HCN gas (especially for railway carriages).
2. **Physical.**—
   Fire (painter's blow-lamp flame ; see also p. 202).
   Hot air.
   Steam.

Chemical.—Nos. (4), (5), (6), and (7) in the first list have already been dealt with. The first four, however, require brief special mention.

For general purposes the gaseous disinfectants should be used chiefly as insecticides. For efficient use as disinfectants the room to which they are applied should be carefully sealed up, and this is a very difficult procedure with the ordinary tropical room.

In a strength far short of that in which they will destroy bacteria, they will, however, act as efficient poisons to mosquitoes and other biting flies which survive in nooks and crannies from one year to another.

(1) *Pesterine.*—This substance is crude petroleum (fuel oil), and is undoubtedly a powerful insecticide, as it instantly kills all fleas, bugs, and other insects that come in contact with it. Its method of application is very simple, as it has only to be brushed on the floors and walls of rooms to a height of about 3 feet. It is very cheap, as the cost of treating an average-sized room

is about one shilling. It is not, however, an elegant preparation; hence its use in better-class houses is open to some objections.

(2) *Kerosene Oil Emulsion.*—This emulsion is made according to the following formula: Common soap, 3 parts; water, 15 parts; kerosene oil, 82 parts.

The soap is dissolved in the water by aid of heat, and the kerosene oil is warmed and gradually stirred into the mixture.

It has been shown that 1 part in 1,000 parts of solution will kill fleas in two minutes.

It should ordinarily be used diluted with 20 parts of water.

(3) *Petrol.*—This fluid was used with equal parts of cyllin for disinfecting plague-stricken houses in Hong-Kong. The mixture has to be made up fresh daily, as the two ingredients undergo chemical changes, producing an inert substance. The emulsion is a powerful insecticide and germicide. All these measures may require repeated use.

Physical.—Experience in India and the Middle East with seriously bug-infested houses tends to prove that flaming with the painter's blow-lamp is the only really permanent eradicator of bugs and their eggs from the crevices of woodwork. Next to this measure, the best agent is the use of hydrocyanic acid gas, but, as indicated above, its use requires skilled and experienced supervision, owing to its deadly properties.

Pellagra probably depends on two or more of the following factors: 1. Infection by unknown specific organism. 2. Dietetic factors. (*a*) Toxic. (*b*) Deficiency of (α) protein, (β) one or other vitamin, or (γ) some unknown substance. 3. Bad conservancy. 4. Effects of sunlight similar to those producing sunburn (R. Soc. Trop. Med. and Hyg., Discussion).

Osler only refers to two main views—viz., "food deficiency" and "infection of some kind" (see als *Pellagra, p. 223*).

EPIDEMIOLOGICAL TABLE OF DISEASES—*Continued.*

Disease.	*Mode of Infection: (a) Causal agent; (b) vector or medium; (c) reservoir.*	*Incubation Period.*	*Isolation or Segregation of Patient.*	*Quarantine of Contacts.*	*Preventive Measures.*
Diphtheria ...	(*a*) Diphtheria bacillus; (*b*) close contact; (*c*) carriers	2 to 10 days	Six weeks, or until three successive daily swabs have been negative, each made not less than 12 hours after discontinuance of local antiseptic	—	Isolation; avoid crowded places; disinfection of discharges and quarters; Schick's test; toxin, antitoxin
Dysentery (amœbic)	(*a*) *Entamœba histolytica*; (*b*) flies and dust; (*c*) carriers	3 to 12 weeks	Until after course of emetine negative examinations of stools have been obtained as follows: 1 in the first week, 1 in the second, and 4 in the third week	—	(1) Isolation; (2) disinfection of excreta
Dysentery (bacillary	(*a*) Bacillus of Flexner or Shiga; (*b*) flies; (*c*) carriers	2 to 7 days	Until examinations of stools and urine have been negative	—	(1) Isolation; (2) disinfection of excreta; (3) vaccines
Enterica (Typhoid paratyphoid A and B)	(*a*) *B. typhosus*, paratyphoid A and B; (*b*) flies, fingers, and food; (*c*) carriers	10 to 14 days; occasionally 3 weeks	Until examinations of stools and urine have been negative	—	(1) Isolation; (2) disinfect most strictly all urine, stools, and everything used in connection with patient; (3) preventive inoculation;

					(4) habitually avoid food without skins and uncooked vegetables; (5) destroy flies
Filariasis	(*a*) *Filaria bancrofti*; (*b*) mosquito, both culicines and anophelines (*Culex fatigans*, *M. rossi*, *Pyretophorus costalis*, *P. africans*, *S. calopus*; (*c*) man	—	—	—	(1) Isolation of the infected; (2) use of mosquito nets; (3) anti-mosquito measures
Dracontiasis (Guinea-worm)	(*a*) *Dracunculus medinensis*; (*b*) infected water; (*c*) *Cyclops quadricornis*	About 1 year	Segregate infected patients	—	Protect water-supply
German measles	(*a*) Unknown; (*b*) air; (*c*) man	9 to 18 days	10 days after appearance of rash	20 days	Isolation and disinfection
Glanders (acute)	(*a*) *B. mallei*; (*b*) contact; (*c*) horse	2 to 3 days	Isolate until convalescent	—	—
,, (chronic)	Ditto	Indefinite	Ditto	—	
Hydrophobia (in man)	(*a*) Unknown	6 days to 2 years; usually about 6 weeks	—	—	—
Rabies (in dog) ...	—	3 to 6 weeks	Dog destroyed if rabid; shut up for 10 days if suspected; quarantine for dogs, 6 weeks	—	—

EPIDEMIOLOGICAL TABLE OF DISEASES—*Continued.*

Disease.	*Mode of Infection: (a) Causal agent; (b) vector or medium; (c) reservoir.*	*Incubation Period.*	*Isolation or Segregation of Patient.*	*Quarantine of Contacts.*	*Preventive Measures.*
Diphtheria ...	(*a*) Diphtheria bacillus; (*b*) close contact; (*c*) carriers	2 to 10 days	Six weeks, or until three successive daily swabs have been negative, each made not less than 12 hours after discontinuance of local antiseptic	—	Isolation; avoid crowded places; disinfection of discharges and quarters; Schick's test; toxin, antitoxin
Dysentery (amoebic)	(*a*) *Entamœba histolytica*; (*b*) flies and dust; (*c*) carriers	3 to 12 weeks	Until after course of emetine negative examinations of stools have been obtained as follows: 1 in the first week, 1 in the second, and 4 in the third week	—	(1) Isolation; (2) disinfection of excreta
Dysentery (bacillary	(*a*) Bacillus of Flexner or Shiga; (*b*) flies; (*c*) carriers	2 to 7 days	Until examinations of stools and urine have been negative	—	(1) Isolation; (2) disinfection of excreta; (3) vaccines
Enterica (Typhoid paratyphoid A and B)	(*a*) *B. typhosus*, paratyphoid A and B; (*b*) flies, fingers, and food; (*c*) carriers	10 to 14 days; occasionally 3 weeks	Until examinations of stools and urine have been negative	—	(1) Isolation; (2) disinfect most strictly all urine, stools, and everything used in connection with patient; (3) preventive inoculation;

Mediterranean fever (Undulant fever)	(*a*) *M. melitensis* and *paramelitensis*; (*b*) goat's milk, food, fingers, flies, cream, and cheese; (*c*) goat	10 to 15 days	Until urine is free of organism	—	(1) As for typhoid; (2) boiling of goat; (3) slaying of infected goats
Measles	(*a*) Unknown; (*b*) contact; (*c*) man	10 to 14 days, usually 12	2 weeks after appearance of rash	16 days	Isolation and disinfection
Mumps	(*a*) Unknown; (*b*) contact; (*c*) man	14 to 23 days; no rash 24 days	Whilst swelling lasts	Usually not practicable; 24 days	Isolation and disinfection
Myiasis [*i.e.*, accidental invasion of body cavities or skin by larvæ of Diptera; varieties, (1) Intestinal; (2) cutaneous]	(*a*) (1) *Musca domestica*; (2) larvæ of *Cordylobia anthropophaga* or allied fly (1 and 2); (*b*) not known how infection takes place; domestic dog is indicted for cutaneous type	—	—	—	—
Oriental sore ..	(*a*) *Leishmania tropica*; (*b*) man, ? dogs	14 days to 1 year	—	—	(1) Paint site of insect bites with tincture of iodine forthwith; (2) warn against personal contact; (3) 22-mesh mosquito net
Pellagra	Food deficiency and infection of some kind (see p. 217)				
Plague (bubonic)	(*a*) *B. pestis*; (*b*) *Xenopsylla cheopis*; (*c*) *Mus norvegicus*, *M. rattus*	2 to 8 days; rarely up to 15 days	Until convalescent, and at least for 1 month	10 days	Isolation and disinfection; preventive inoculation; destruction of rats
Plague (pneumonic)	(*a*) *B. pestis*; (*b*) droplet infection; (*c*) rat.	Usually 2 to 8 days	—	7 days	Isolation and careful disinfection

* Possibly an ultramicroscopic organism may be the cause, and not the bacillus of Pfeiffer.

…LOGICAL TABLE OF DISEASES—*Continued.*

Disease.	…ection: … causal agent; (*b*) vector or medium; (*c*) reservoir.	*Incubation Period.*	*Isolation or Segregation of Patient.*	*Quarantine of Contact.*	*Preventive Measures.*
Influenza … …	(*a*) *B. influenzæ* (Pfeiffer's*); (*b*) droplet infection; (*c*) carriers	1 to 5 days	As far as possible during illness	—	Avoid overcrowding; segregation of the sick; use of masks; disinfect discharges; mild formamint gargle; inoculation
Jaundice:					
(1) Bacterial	(1) (*a*, *b*, *and c*) Unknown	3 to 6 days	As for enteric	—	Disinfect urine, fæces, and blood sputum; protect foods; destroy rats and improve sanitation
(2) Spirochætal	(2) (*a*) *Leptospira icterohæmorrhagica*; (*b*) brown rat (*Mus norvegicus*); (*c*) man	6 to 8 days	Until urine free from spirochætes, usually 6 weeks		
Kala-azar (Leishmaniasis)	(*a*) *Leishmania donovanii*; (*b*) ? dogs, fleas, *Cimex rotundatus* (now apparently discredited); (*c*) man	2 to 3 weeks to several months	During illness	Until removed from infected houses and rendered vermin-free	(1) Isolation of patient; (2) disinfection; (3) improve housing; (4) destroy infected animals—*e.g.*, dogs
Malaria (quartan, benign tertian, malignant tertian)	(*a*) *Plasmodium malariæ*, *P. vivax*, *P. falciparum*; (*b*) Anopheles varieties; (*c*) infected man	3 weeks (quartan), 2 weeks (benign tertian), 8 to 12 days (malignant tertian)	Until three negative blood examinations for the malarial parasites have been obtained patients should be strictly guarded against mosquito bites		Destruction of all mosquitoes; protection with wire gauze mosquito net (18 meshes to 1 inch), and take 10 grains of a soluble salt of quinine on a full stomach at night

Mediterranean fever (Undulant fever)	(*a*) *M. melitensis* and *paramelitensis*; (*b*) goat's milk, food, fingers, flies, cream, and cheese; (*c*) goat	10 to 15 days	Until urine is free of organism	—	(1) As for typhoid; (2) boiling of goat; (3) slaying of infected goats
Measles	(*a*) Unknown; (*b*) contact; (*c*) man	10 to 14 days, usually 12	2 weeks after appearance of rash	16 days	Isolation and disinfection
Mumps	(*a*) Unknown; (*b*) contact; (*c*) man	14 to 23 days; no rash 24 days	Whilst swelling lasts	Usually not practicable; 24 days	Isolation and disinfection
Myiasis [*i.e.*, accidental invasion of body cavities or skin by larvæ of Diptera; varieties, (1) Intestinal; (2) cutaneous]	(*a*) (1) *Musca domestica*; (2) larvæ of *Cordylobia anthropophaga* or allied fly (1 and 2); (*b*) not known how infection takes place; domestic dog is indicted for cutaneous type	—	—	—	—
Oriental sore ..	(*a*) *Leishmania tropica*; (*b*) man, ? dogs	14 days to 1 year	—	—	(1) Paint site of insect bites with tincture of iodine forthwith; (2) warn against personal contact; (3) 22-mesh mosquito net
Pellagra	Food deficiency and infection of some kind (see p. 217)				
Plague (bubonic)	(*a*) *B. pestis*; (*b*) *Xenopsylla cheopis*; (*c*) *Mus norvegicus*, *M. rattus*	2 to 8 days; rarely up to 15 days	Until convalescent, and at least for 1 month	10 days	Isolation and disinfection; preventive inoculation; destruction of rats
Plague (pneumonic)	(*a*) *B. pestis*; (*b*) droplet infection; (*c*) rat.	Usually 2 to 8 days	—	7 days	Isolation and careful disinfection

* Possibly an ultramicroscopic organism may be the cause, and not the bacillus of Pfeiffer.

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APPENDIX I

METEOROLOGY

METEOROLOGY is the science which has for its object the observation and interpretation of atmospheric phenomena.

The phenomena which concern the tropical hygienist are:

1. Temperature.
2. Atmospheric humidity.
3. Rainfall.
4. Atmospheric pressure.
5. Winds.

1. **Temperature.**—Temperature is recorded by thermometers, and the varieties with which the health officer is concerned are: (1) The ordinary, (2) the maximum, and (3) the minimum.

(1) *The Ordinary Thermometer.*—This instrument is too well known to require any description.

(2) *The Maximum Thermometer.*—The best variety is Negretti and Zambra's, as it is less liable to get out of order than Phillips's thermometer.

Registration is effected by the mercurial column itself in the following manner: The bore of the thermometer tube is reduced in section close to the bulb in such a way that, whilst the expansion of the mercury is sufficient to force the liquid past the obstruction, the cohesion of the metal is insufficient to draw it back again when the temperature falls.

If the instrument be set so as to agree with an ordinary thermometer, and be examined after a time, when the temperature has risen above that which was prevailing when the setting took place, the amount of mercury in the tube above the contraction will represent the precise amount of mercury forced past the contraction when the temperature was the highest, and thus will measure the temperature. The thermometer should be slightly inclined, bulb downwards, before reading, so as to let the separate portion of the column flow gently back to the contraction.

In order to set this thermometer, it should be held

bulb downwards and shaken. The weight of the separated mercurial column will have the effect of causing all the superfluous mercury to return past the contraction into the bulb, and the instrument will soon come to indicate the same temperature as that of the air, and will be ready for use again.

The hands must be kept away from the bulb during the process of setting.

(3) *The Minimum Thermometer.*—The variety best adapted for ordinary use is Rutherford's. This is a spirit thermometer with a metallic index, which moves with little difficulty in the tube. This index is entirely enveloped in the spirit, and the action is as follows: The index is allowed to run down to the end of the column by sloping the thermometer with the bulb uppermost, and when so set is placed in a nearly horizontal position. When the temperature rises, the spirit flows past the index without disturbing it. When, however, the temperature falls below that at which the instrument was set at starting, the force of the capillary attraction between the spirit and the index draws the latter back with the spirit. Its upper end remains flush with the extremity of the column while it is receding, and ultimately marks the lowest temperature, as when the temperature rises the index is left behind.

These thermometers are liable to a serious defect owing to the fact that a portion of the spirit becomes volatilized, and is then condensed in the upper end of the tube, so that the continuous column is curtailed by a length of perhaps several degrees.*

The temperature of the air depends upon (1) altitude, (2) latitude, (3) distance from the sea, (4) temperature of the sea, and (5) exposure. Of these, probably the two most important are altitude and latitude. The mean temperature falls about 5·5° C. for each 1,000 metres of ascent.

An isotherm is a line connecting places with the same mean temperature. An isothermal map is a map of an area of differing extent, which shows lines which may be either curved or straight, of equality of temperature over a given period of time. They must be looked upon as only approximately correct regarding the superficial distribution of temperature.

* *To remedy this defect swing the thermometer to and fro, bulb downwards,* and place in upright position for an hour.

To find the actual mean temperature, monthly or annual, of any place crossed by an isotherm, subtract the height of the place in metres by 150 to 200, as the case may be, from the value of the isotherm in degrees Centigrade, or the height in feet divided by 270 or 365 from the value of the isotherm in degrees Fahrenheit; by 150 where the vertical gradient averages 1° C. for every 150 metres; by 200 where the gradient averages 1° C. for every 150 metres; and by 270 or 365 respectively where the vertical gradient averages 1° F. for every 270 or 365 feet respectively (Glaister).

2. **Atmospheric Humidity.**—Next to the actual temperature, one of the most important of meteorological observations in the tropics is the estimation of humidity, as most of the unpleasant effects of a tropical climate are due to excess of moisture in the atmosphere.

Two kinds of humidity are described:

(1) Absolute.
(2) Relative.

(1) *Absolute.*—Absolute humidity is the actual amount of watery vapour in a fixed quantity of air.

(2) *Relative.* — Relative humidity is generally the humidity given in meteorological tables. It is the amount of watery vapour contained in the air compared with the actual maximum.

The lowest relative humidity is 25 per cent.; under 55 is low, between 55 and 75 moderate, and over 85 excessive.

Hygrometry is the art of estimating the amount of watery vapour in the air by means of hygrometers.

There are various kinds of hygrometers, the observations of the amount of moisture in the air being taken in a direct as well as in an indirect manner; but the wet and dry bulb hygrometer is by far the most convenient instrument for use under ordinary circumstances.

The instrument consists of two thermometers, the bulb of one being coated with muslin, and kept moistened with water. The principle of its action is that, as long as the atmosphere is not saturated with vapour, evaporation will take place from any free water surface, such as the moist coating of the wet bulb. If, then, the air be saturated, no evaporation is possible, and the two thermometers, the dry and the wet bulb, will read alike.

If the air is not saturated, the coating of the damp bulb will give off vapour, and the temperature of that thermometer will fall until a certain point is reached intermediate between the temperature of the air and the "dew-point."

The dew-point is that temperature at which the air is saturated with moisture so that the least further fall in temperature causes a deposit of water in the form of dew.

The usual mode of regulating the supply is to keep a small reservoir of water close to the damp bulb, and to establish a connection from the one to the other by means of a few threads of cotton. The cotton should be long enough to reach a few inches from the lowest part of the bulb, and should be carried sideways, so as to dip in the vessel of water, when it will act as a capillary siphon and keep the bulb constantly moist.

The management of this instrument requires some special precautions—viz.: (1) The covering of the wet bulb must be very thin, else there is danger that the thermic equilibrium will not be established between the outside of the coating, where the evaporation is going on, and the actual bulb; (2) the supply of water must be very carefully regulated, so that the bulb shall be constantly moist.

The little water reservoir should be placed as far as possible from the dry, which should not receive moisture from any source whatever. Of course, if moisture be found on a dry bulb, this should be wiped and left for a while to assume the true temperature of the air. The water of the wet bulb should be distilled.

The water should be replenished *after*, or some considerable time *before*, observing, because observations are incorrect if made while the water is warmer or colder than the air.

The muslin should be well washed before being applied, and occasionally whilst in use, and should be changed once or twice a month, or even oftener. Accuracy depends much on cleanliness and a proper supply of fresh water.

Glaister's tables give the relative humidity corresponding to all ordinary readings of the wet and dry bulb thermometers, so that the elaborate calculations given in some textbooks are rarely required.

3. **Rainfall**.—The estimation of the rainfall is always of

interest in the tropics, as we have seen that the climate of a tropical region depends almost entirely upon it.

There are numerous patterns of rain-gauges, but the best for general use has a circular collecting funnel, usually 8 inches in diameter, of which the area is accurately known. The rain is caught in a receiver, and measured in a graduated glass. The upper edge of the funnel is fitted with a vertical rim about 6 inches in depth, with a stout brass ring ground to a knife-edge on top. Great care should be taken to ensure that the mouth of the funnel is not dented, for if the area be not a true circle the full amount of rain will not be collected. The sole reason for preferring circular gauges to square ones is that the latter get more easily out of shape than the former.

4. **Atmospheric Pressure.** — The pressure of the atmosphere is measured by barometers, which are of two kinds—viz., (1) mercurial, (2) aneroid.

(1) *The Mercurial Barometer.*—The Kew, Fitzroy, and Fortin are well-known varieties of this type of instrument. They consist essentially of a tube of glass about 34 inches in length, closed at one end, filled with mercury, and placed vertically with the open end dipping into a reservoir containing mercury. The mercury should be pure, of the specific gravity of 13·594. The mercury does not entirely fill the tube so placed, but, according to the changes of the atmospheric pressure, occupies at the level of the sea from 31 to 27 inches of the tube, measured above the mercury in the cistern. The space above the mercury in a properly filled barometer tube contains nothing but a little of the vapour of mercury.

Another familiar type is the siphon barometer, in which the trough or cistern, as it is technically called, is dispensed with. The mercury is contained in a U-shaped tube, the shorter limb of which is open at the end. The reading of the barometer is the difference of level in the two legs.

The wheel barometer is a variety of siphon barometer in which the movements of the mercury are conveyed by a simple mechanical contrivance to a pointer which indicates on a dial the weather condition usually associated with various barometric readings.

(2) *The Aneroid Barometer.*—For ordinary use in the tropics these are in great favour on account of their convenient size and portability.

In the aneroid atmospheric pressure is measured by its effect in altering the shape of a small hermetically sealed metallic box from which almost all the air has been withdrawn, and which is kept from collapsing by a spring. The top of the box is corrugated.

When the atmospheric pressure rises above the amount which was recorded when the instrument was made, the top is forced inwards, and, vice versa, when pressure falls below that amount the top is pushed outwards by the spring. These motions are transferred by a system of levers and springs to a hand which moves on a dial like that of a wheel barometer.

It is at once evident that the instrument must be graduated experimentally, as it cannot measure pressure absolutely, but affords indications relatively to a mercurial barometer (its sensibility depending, *inter alia,* on the quality of the metal of which the box is made).

The principle of the metallic (Bourdon's) barometer is somewhat similar to that of the aneroid.

Aneroids are very sensitive, but, unfortunately, they do not preserve their accuracy. If a table of corrections be determined for an aneroid, it will be found that after a time it has undergone some change, and that the values of the corrections will require alteration, so that recomparison with a standard barometer will be necessary. In every case of such comparison the readings of the mercurial barometer should be reduced to 32°.

A most serious objection to the scientific utility of these instruments is their liability to injury owing to rust or to the alteration of force in the springs used for their construction.

For concerted observations accurate mercurial barometers are indispensable.

In ascending altitudes the instrument is very useful; all that has to be done is to take the barometric reading at the bottom of the hill or mountain, and deduct from it the reading at the desired altitude. The difference, ignoring decimal points, multiplied by nine, will give approximately the height in feet.

Example :

Reading at start	31·00
Reading at desired height	28·00
	$300 \times 9 = 2{,}700$ feet.

5. **Winds.**—Winds, as we have seen, play an important part in the determination of climate, so that their study holds an important place in meteorological observations.

Their velocity and pressure is measured by anemometers.

Robinson's anemometer is the only one in general use.

It consists of four bars rotating horizontally round an axis connected by a mechanical contrivance with several recording dials. Each bar has fitted at right angles to its extremity a small cup.

The wind impinges on the cups at the end of the bars, and causes the apparatus to revolve round the axis.

The speed has a direct relation to the size of the cups and the velocity of the wind. In Negretti's latest instrument it is self-recording.

The position selected for the instrument should always be one which will secure the fullest exposure to wind from all quarters.

FOUND IN HOUSES.

noxys calcitrans, Linn. (the Stable-Fly).

st over ¼ inch ; broader and more thickset than (1) or rkish grey ; thorax marked with four conspicuous, itudinal stripes ; abdomen spotted clove brown, eous buff patches, the spots usually more conspicu- ; space between eyes, male one-quarter, in female e-third, total width of head ; proboscis black and ting horizontally in front of head, *visible from above ;* ongitudinal vein in wing somewhat bent up, but not ply as in (1). Termination distinctly separated from n above it. Swarms in cowsheds. Common about stables, and also on fences and gates in pasture- ng fly ; both sexes suck blood, attack human beings es and cattle, and inflict a painful bite.

n length ; elongate, resembling banana in shape ; y straight, other curved, with a broad deep groove le ; laid in small masses in accumulations of moist g vegetable matter (grass mowings, horse-droppings, nperature of about 70° F. hatches in two or three

colour and general appearance to the larva of (1) ; by the plates on posterior end of body, bearing rtures, being much smaller and circular (instead of ach plate being straight), and from four to six times ith the opening straight instead of sinuous. Length n just under ⅓ inch.
conditions this stage lasts from fourteen to twenty-

stnut brown ; barrel-shaped, cylindrical, front end ted ; precisely similar in general appearance to pupa be distinguished by size of, and distance between, ratory plates of larva, which are still visible ; normal ess than ¼ inch. Stages last from nine to thirteen

s, No. 5.

[*Between pages* 234 *and* 235.

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